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Faculty of Engineering & the Built Environment
Centre for Transport Studies



# Potential Market Overlap between the Gautrain and the PRASA Modernisation Program

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Dissertation submitted in partial fulfilment of requirements for award of MSc (Eng.) Civil Engineering

Supervisor: Prof Mark Zuidgeest

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# Abstract

The Gauteng Province is the only province in South Africa with two rail services, namely Metrorail, operated through the Passenger Rail Agency of South Africa (PRASA), and Rapid Rail, known as the Gautrain, operated by the Gautrain Management Agency (GMA). It is widely known that these rail services do not compete for passengers as they currently serve different markets. Based on passenger survey data, PRASA currently serves the Low and Middle Income markets while the Rapid Rail serves the Upper Middle and High Income markets.

PRASA has published their modernisation plans, with a focus on upgrading the Gauteng Metrorail network in the future. It is currently unclear whether these upgrades could result in a rail market overlap between Rapid Rail services and the PRASA Modernisation services. The rail market overlap holds two scenarios, a complimentary overlap and a competitive overlap. A complimentary overlap involves one rail service integrating with another, resulting in a potential increase in patronage for both services. Such an overlap is aligned with the Gauteng 25-Year Integrated Transport Master Plan (GITMP25) vision, whereby the Gauteng public transport system is integrated across multiple modes and services and would thus promote the use of the public transport system. For this overlap to take place, the rail services should serve similar markets, different geographical nodes and integrate at key transfer nodes while not competing for passengers along corridors. A competitive overlap is one where two rail services serve similar, if not the same, markets and nodes and compete for passengers along the transport corridors. Such an overlap does not support the vision of the GITMP25 as a competitive overlap requires fully operational infrastructure for both services, only to divide existing public transport users between the two services. This form of overlap is not sustainable and does not attract new public transport users to the services.

In order to investigate whether the Rapid Rail and PRASA Modernisation services will have a competitive overlap, it is necessary to understand the existing and potential future rail operators' markets, passengers' travel behaviour and evaluate the services' geographical overlap. Once the overlap is identified and quantified, the results will be able to guide future transport planning to minimise competitive overlap in rail services and focus on complimentary overlap to help build an integrated public transport system for the Gauteng Province. To demonstrate this, this study evaluated the existing rail services in the Gauteng Province and defined the respective socio-demographic market segmentation and mode choice drivers. A hypothetical rail market was developed for the proposed PRASA Modernisation service, aligning with the proposed service's upgrade plans. A Multi-criteria Analysis (MCA) tool was developed to align the Rapid Rail, existing Metrorail and proposed PRASA Modernisation rail services with their respective markets in terms of income brackets. Thereafter, MCA was used to determine the overlap in markets between the three rail services.

The MCA identified that the PRASA Modernisation service would expand the Metrorail market into the Upper Middle Income category as a result of the service's expected improvements. The PRASA Modernisation Upper Middle Income market was therefore identified as the potential overlapping market with the current Rapid Rail service. The potential competitive market overlap between the Rapid Rail and PRASA Modernisation rail services were evaluated in terms of geographical market overlap, trip pattern overlap and trip making overlap. The ultimate overlap between the Rapid Rail and the PRASA Modernisation services resulted in 12% of the overall Rapid Rail patronage.

Finally, an estimated uptake of the overlapping market was developed using the quantitative mode choice drivers, namely travel time and travel cost. The weightings of these mode choice drivers were aligned with that of the Rapid Rail market and the travel time and travel cost of each rail service was normalised over an average trip distance between Pretoria and Johannesburg CBDs. The estimated service uptake resulted in 58% of the overlapping market remaining to use the Rapid Rail service and 42% of the overlapping market shifting to use the PRASA Modernisation service. However, the Rapid Rail park-and-ride facilities are used by more than 40% of the Rapid Rail passengers. Without this infrastructure at the PRASA Modernisation stations, the potential uptake of the PRASA Modernisation service from existing Rapid Rail services could be diminished from 41% to 25% due to the lack of an integrated Metrorail system with private cars. The final competitive overlapping market between the Rapid Rail and PRASA Modernisation services resulted in 3 – 5% of the total Rapid Rail patronage.

The research study concludes that the competitive overlap between the Rapid Rail and PRASA Modernisation services would be negligible as these services will continue to serve different markets. It is therefore recommended for the PRASA Modernisation program to be implemented to assist in the much needed rejuvenation of the Gauteng Metrorail service. It was further recommended that the PRASA Modernisation program incorporates integrated feeder and distributor services, strengthening the attractiveness of the PRASA Modernisation service and aiding in the GITMP25's vision of developing an integrated and efficient transport system in Gauteng.

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# 1. INTRODUCTION

## 1.1. Research Problem

Gauteng Province is considered to be the economic hub of South Africa. Even though the province only makes up 1.4% of South Africa's geographical land size, it is home to 24% of South Africa's population (Lehohla, 2014) and contributes towards 35% of the national Gross Domestic Product (GDP) (Creecy, 2016). Daily commuting in Gauteng is therefore critical to the stability and growth of the country's economy.

The Gauteng 25-Year Integrated Transport Master Plan (GITMP25) has been developed as a road map to plan, develop and regulate an efficient and integrated transport system for the Gauteng province over the next 25 years (Gauteng Province - Roads and Transport, 2013). The vision of the GITMP25 is for Gauteng to have "*An integrated and efficient transport system that promotes sustainable economic growth, skills development and job creation, fosters quality of life, socially includes all communities and preserves the environment*" (Gauteng Province - Roads and Transport, 2013).

The GITMP25 has identified the following ten key interventions which aims to mobilise the plan and aid in its successful implementation:

Land Use Development

1. Subsidised housing provision within urban core areas;
2. Facilitating local economic development outside the urban core;
3. Land use densification in support of public transport;

Strategic Public Transport Network

4. Reinforcing passenger rail network as the backbone of the system;
5. Extending the integrated rapid and road-based public transport networks;
6. Capacity building in the transport industry;

Freight Transport

7. Strengthening intermodal freight hubs;

Road Transport

8. Travel demand management;
9. Mainstreaming non-motorised transport; and
10. Continued provincial wide mobility.

Gauteng is the only province in South Africa with two rail services, namely Rapid Rail, known as the Gautrain, operated by the Gautrain Management Agency (GMA), and Metrorail, operated through the Passenger Rail Agency of South Africa (PRASA). The full Rapid Rail commuter service commenced in 2012 and has exceeded patronage growth forecasts. The Rapid Rail service is a reliable mode of public transport which consists of a market of choice users. The Gauteng Metrorail service first started operation in the late 19$^{th}$ century and expanded to serve the major employment nodes in Gauteng. However, the Metrorail quality of service has deteriorated and of late the service is known to be unreliable with many delayed and cancelled services. The Gauteng Metrorail serves a public transport captive market who are unable to afford private transport or more reliable public transport modes.

The GITMP25 has considered the status quo of the Gauteng rail services and formulated two interventions to strengthen the rail services in the Province's future public transport network. *Intervention 5 – Extending the integrated rapid and road-based public transport networks* acknowledged the successes of the existing Rapid Rail service and supports the extension of these services to reach Rapid Rail markets in areas where no viable public transport mode currently services these markets. *Intervention 4 – Reinforce the passenger rail network as the backbone to the public transport system* acknowledged the current shortcomings of the Metrorail service and supports plans to rejuvenate the service through the PRASA Modernisation program. *Intervention 8 – Ensuring continued provincial wide mobility* and *Intervention 10 - Continued provincial wide mobility* aim to promote public transport as the sustainable mode of travel in the future. The GITMP25 estimated that should the Province's transport network remain unchanged, the average road speed in the peak hour will deteriorate to 14 km/h by 2037. Such lack of mobility will negatively affect the Province and the country's economy and future growth. Travel demand management has therefore been identified to aid in reducing congestion through, amongst others, promoting ride-sharing, promoting non-motorised transport and improving public transport infrastructure to attract car users.

PRASA has published their modernisation plans, with a focus on upgrading the Gauteng Metrorail network in the future. It is currently unclear whether these upgrades could result in a rail market overlap between the existing Rapid Rail services and the PRASA Modernisation services. The rail market overlap holds two scenarios, a complimentary overlap and a competitive overlap. A complimentary overlap involves one rail service integrating with another, resulting in a potential increase in patronage for both services. Such an overlap is aligned with the GITMP25 vision, whereby the Gauteng public transport system is integrated across multiple modes and services and would thus promote the use of the public transport system. For this overlap to take place, the rail services should serve similar markets, different geographical nodes and integrate at key transfer nodes while not competing for passengers along corridors. A competitive overlap is one where two rail services serve similar, if not the same, markets and nodes and compete for passengers along the transport corridors. Such an overlap does not support the vision of the GITMP25 as a competitive overlap requires fully operational infrastructure for both services, only to divide existing public transport users between the two services. This form of overlap is not sustainable and does not attract new public transport users to the services. Due to the unfavoured impacts of a competitive overlap, this study focuses on quantifying the competitive overlap between the Rapid Rail and the PRASA Modernisation services. Quantifying this overlap could aid in the Gauteng Province's future transport planning to optimise the implementation of rail services and limit potential competitive overlap.

In order to investigate whether the Rapid Rail and PRASA Modernisation services will have a competitive overlap, it is necessary to understand the existing and potential future rail operators' markets, passengers' travel behaviour and evaluate the services' geographical overlap. Once the overlap is identified and quantified, the results will be able to guide future transport planning to minimise competitive overlap in rail services and focus on complimentary overlap to help build an integrated public transport system for the Gauteng Province.

## 1.2. Research Objectives

The main objective of this research study is to determine whether the PRASA Modernisation program could result in a competitive market overlap with the existing Rapid Rail services, leading to a potential shift of Rapid Rail passengers to PRASA Modernisation services.

## 1.3. Questions

In order to meet the research objectives, the following questions will be addressed:

- Where are the existing Gauteng rail services located?
    - How do the rail services relate to the population and employment settlement patterns in Gauteng (Metrorail and Rapid Rail separately)?
- What are the socio-demographic characteristics of the Metrorail service passengers?
- What are the socio-demographic characteristics of the Rapid Rail service passengers?
- What are the mode choice drivers of the Metrorail service passengers?
- What are the mode choice drivers of the Rapid Rail service passengers?
- What are the PRASA Modernisation Program's plans?
- What are the hypothetical mode choice drivers of the PRASA Modernisation service passengers?
- Can the hypothetical mode choice drivers of the PRASA Modernisation service passengers define the socio-demographic characteristics of these passengers?
- Is there a competitive overlap in the proposed PRASA Modernisation and Rapid Rail markets?

## 1.4. Research Structure

The reporting structure used for this research study is presented in Figure 1-1. The research components, consisting of the study introduction, literature review and study area were undertaken first in order to develop the foundations off which the research was based. Thereafter, the data requirements and data collection are discussed to gain an understanding of the inputs used in the study. The research methodology presents the approach followed for the study, followed by the data analysis results and discussion and conclusion.

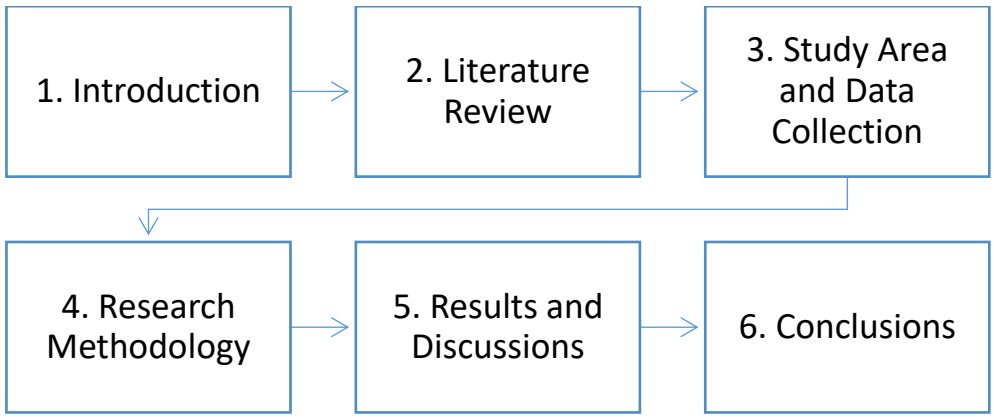


*Figure 1-1: Research Framework*

# 2. LITERATURE REVIEW

This literature review explores the resulting impacts of competitive public transport services in terms of policy decision making, economics and the ownership of public transport services. Thereafter, focus is drawn to the travel behaviour in the Gauteng Province, which has been shaped over time by various influences, including land use settlement patterns and socio-demographics. This literature review also discusses the spatial land use development in the Gauteng Province and the impact of land use settlement patterns on the transport system's demand and supply. It further discusses the existing and planned future public transport supply within the Province and the resulting travel behaviour. This literature review also presents the driving factors for mode choice and explores these factors in a local South African context. Finally, this literature review explores the various analysis techniques related to Multi-criteria Analysis (MCA).

## 2.1. Competition of Public Transport Services

Investment in transport plays a significant role in the economic growth of a country. Transport investments, particularly from government expenditures, can result in a complimentary nature between two types of transport modes or in a competitive nature (Tsekeris, 2011).

Complementary investments of various transport modes are guided by a number of influences, including policy guidelines, financial requirements, economic and social needs of the travel market, access conditions including geographical constraints and implementation and operational regulation. On the other hand, competitive transport investments can be seen to have significant impacts on the spatial, social and economic development and influences the planning of future transport projects (Tsekeris, 2011). A fine line exists between the complementary and competitive nature of transport investments. For example, by investing in different transport modes, the travel cost could be reduced as a result of an increase in network connectivity and integrated services. However, the new services may compete with existing services for patronage and may also require additional investment to integrate with the existing services. The integration connectivity could result in additional distance travelled, whereas without the integration the new services would not need to travel the extra distance (Combes & Linnemer, 2000).

Research studies have identified that economic growth, population size and population density are key drivers influencing the decision making around transport infrastructure investments. These studies also highlighted that political influence is a major role player during the decision making process (Tsekeris, 2011). A case study was undertaken in Israel which evaluated a policy decision, made by the Israeli government, to introduce competition into the public transport system. The case study, undertaken by Sharaby & Shiftan (2008), evaluated the impact of the competitive bus services on transit fares, level of service and patronage along the competitive routes.

The Israeli government's main objective for introducing the competitive bus services was to dilute the monopolistic market of the existing public transport sector. Through political influence the new services aimed to create a more competitive market, led by economic policy. Further objectives included to increase the bus mode share through an increase in patronage on the system, improve the service quality while monitoring this through a level of service index, improve the economic

viability of the service, incorporate new technology systems into the service and encourage the private sector to invest in the system in order to reduce dependency on the government for funding.

Sharaby & Shiftan (2008) assessed the economic outcomes of the competitive bus system in Israel, six years after its implementation. Economic benefits were observed, whereby the resulting bus transit fares were reduced due to the competitive nature of the system. This proved beneficial to the passengers. Patronage was also observed to increase on at least half of the bus routes, as the competitive market resulted in a more attractive option to travellers. The competitive bus services were awarded through government tenders and the tenders included royalties to be paid back to the government as a part of the contract. The competitive bus system therefore also reduced government subsidies (Sharaby & Shiftan, 2008). However, it is important to note that in this case study the financial risk shifted from the government to the private sector and much of this success is attributed to the willingness from the private sector to take on this risk and have the financial backing to do so.

Another study, undertaken by Scheffler, Hartwig, & Malina (2013), evaluated how competitive tendering influences the efficiency of bus routes in Germany. It was found that competitive tendering affected the service efficiency in a positive manner. If one operators's level of serivce deteriorated, passengers would no longer consider that service as meeting their travel needs and passengers would then subsequently shift to a service which does indeed meet their travel needs. The competitive nature therefore resulted in all operators maintaining or improving their public tranposrt efficiency in order to be considered in the pool of high quality services. The study also investigated the impact that the ownership structure may have on the serivce efficiency. It was found that multi-utility companies were not able to provide the same level of efficiency as compared to transport dedicated companies. It was further found that the exclusive privatisation linked to multi-utility companies did not improve efficiency either (Scheffler, Hartwig, & Malina, 2013). As a result, the improvement of efficiency was found to be linked to limiting the extent of utilities managed by a company rather than being publicly or privately owned.

## 2.2. Spatial Land Use Development in Gauteng

### 2.2.1. Historical Spatial Development Influences

The spatial land use development within the Gauteng Province was influenced by historical settlement in Tshwane in the mid-1800s and the expansion of the mining industry in the early 1900s. The mining belt settlement patterns developed along an east-west axis, stretching from Springs in the east, through Johannesburg to Randfontein in the west (McKay, et al., 2017). The industrial development in the 1950s resulted in settlement along the southern border of the Gauteng Province. These settlement patterns resulted in sparsely located cities and towns connected with dominant north-south and east-west connectivity axes, as shown in Figure 2-1.

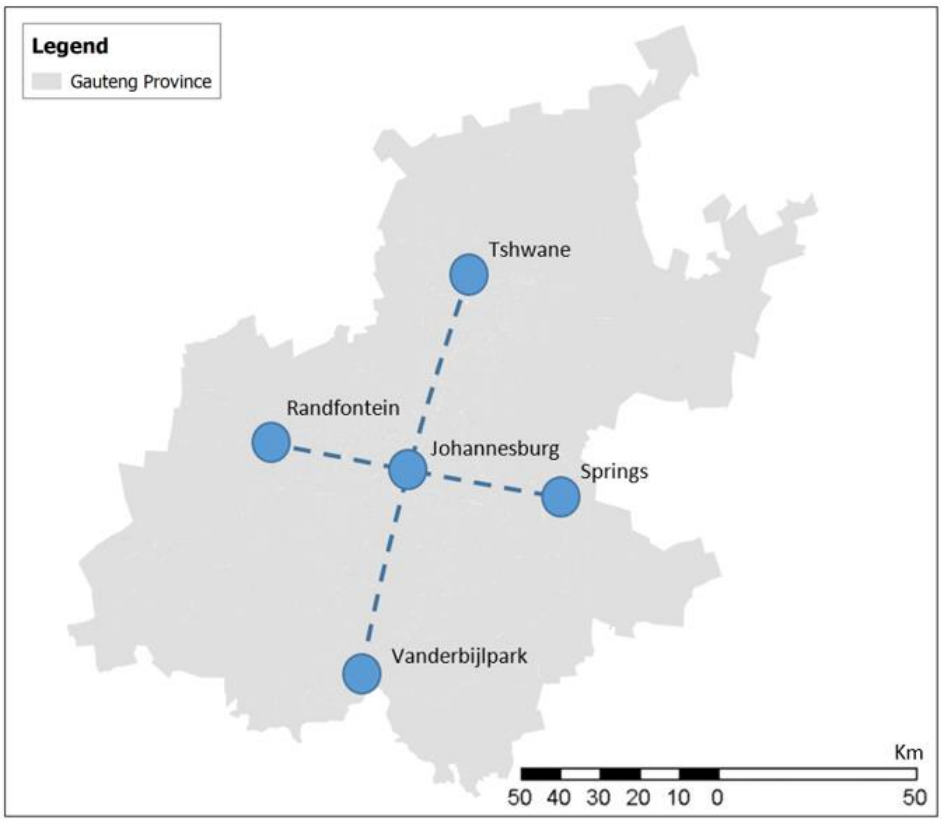


*Figure 2-1: Gauteng Early Settlement Patterns*

The apartheid planning further influenced the Gauteng spatial land use development by locating the black African, Coloured and Indian population in the peri-urban space (townships), as shown in Figure 2-2 (McKay, et al., 2017). The Tshwane and Johannesburg nodes developed into the main employment nodes in Gauteng, however, the apartheid planning entrenched sparsely populated spatial development across the Province, resulting in long travel distances between the residential areas and places of work. The average commute distance between the major Gauteng townships and the Tshwane and Johannesburg Central Business Districts (CBD) is 26 kilometres. These long commuting distances have resulted in over 80% of public transport users and 40% of private car users spending more than 10% of their monthly income on transportation (McKay, et al., 2017).

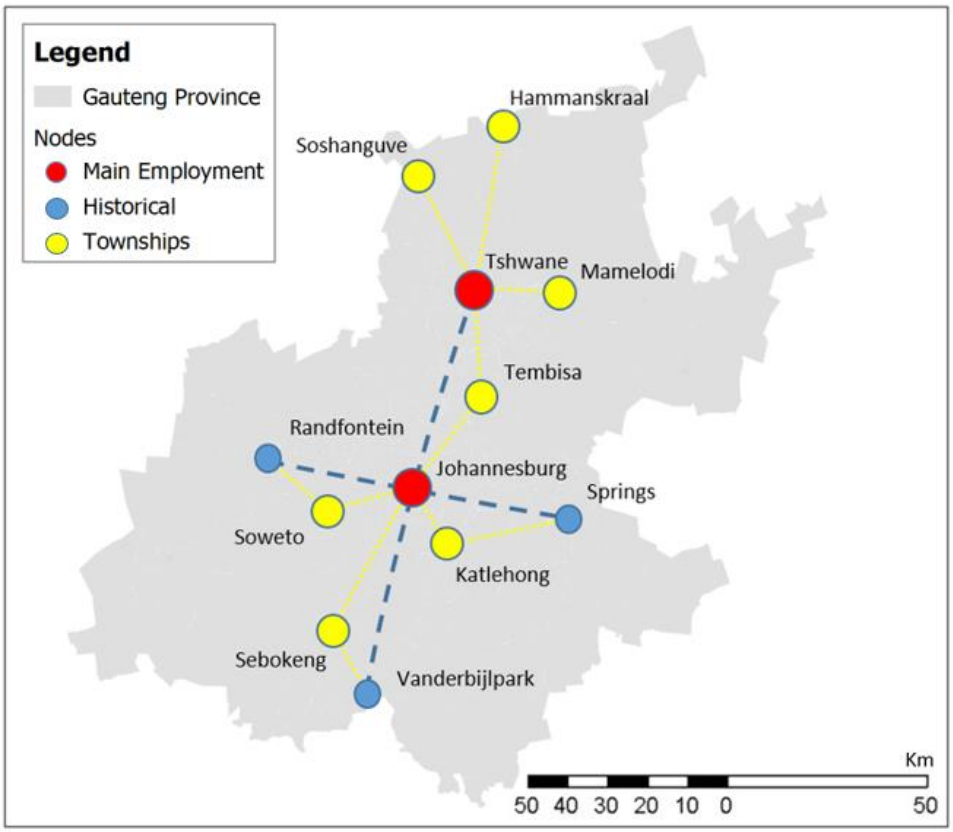


*Figure 2-2: Gauteng Major Township Locality*

### 2.2.2. Future Spatial Development Plans

The future spatial development of Gauteng will be limited to some degree by the existing land use and demographics. The Gauteng Spatial Development Framework (GSDF) 2011 has however identified various development initiatives for the future development of the Province. The key objective of future development within Gauteng is to limit further urban sprawl, by focussing development around the urban core.

The guiding principles, set out in the GSDF 2011 and presented in Figure 2-3, for the future development of Gauteng are as follows (Gauteng Provincial Government, 2011):

- Restricting urban sprawl as a basic tenet of the sustainable city;
- A densification policy for lower- density residential townships and suburbs;
- Harmonising housing provision and subsidies within the wider urban system with particular reference to the Breaking New Ground Policy;
- Transportation – a sustainable mobility solution; and
- The CASE (Cities as Sustainable Ecosystems) Principles of sustainable urban development.

The GSDF 2011 discussed the unsustainable impacts of urban sprawl and how these affect both the communities and the governing streams. Urban sprawl requires the extension of basic infrastructure to the outlying communities, including electricity, water and sanitation and transportation. The costs associated with the implementation of the basic infrastructure in the outlying areas of the urban node are considerably higher than within the urban node. The restriction of urban sprawl would therefore limit the increase of living costs and focus on infrastructure improvements within the urban nodes.

Further to the restriction of urban sprawl, the GSDF 2011 proposed a densification policy of lower density residential areas. The policy suggests that the growth of the city be absorbed into the existing residential suburbs, by means of developing activity spines with housing densification along these activity spines. The activity spines would focus on mixed-use developments with the aim to enhance local economies and develop sustainable living environments for the communities.

The GSDF 2011 identifies that the current approach towards public housing has challenges, leading to an unsustainable urban structure. The public housing delivery has not been able to meet its targets, and as a result, the GSDF 2011 recommends that a review of the integrated planning be undertaken to identify the re-direction required to solve the current public housing delivery challenges.

The GSDF 2011 identifies that the growing urban node of Gauteng must be supported by a sustainable transportation system. The GSDF 2011 further notes that the transportation investment cannot focus solely on private vehicle transportation and in order to become sustainable public transport must become the primary focus of transportation investments.

The GSDF 2011 highlights the CASE Principles as the guidelines which must be followed to develop the Gauteng node into a sustainable urban development. The key principles highlighted are as follows:

- Provide a long-term vision for cities founded on sustainability;
- Intergenerational, social, economic and political equity;
- Achieve long-term economic and social security;
- Recognise the intrinsic value of biodiversity and natural ecosystems, protecting and restoring them;
- Enable communities to minimize their ecological footprints;
- Build on the characteristics of ecosystems in the development and nurturing of healthy and sustainable cities;
- Recognise and build on the distinctive characteristics of cities, including their human and cultural values, historical and natural systems;
- Empower people and promote participation;
- Expand and enable cooperative networks to work towards a common, sustainable future;
- Promote sustainable production and consumption through appropriate use of environmentally sound technologies and effective demand management; and
- Enable continual improvement based on accountability, transparency and good governance.

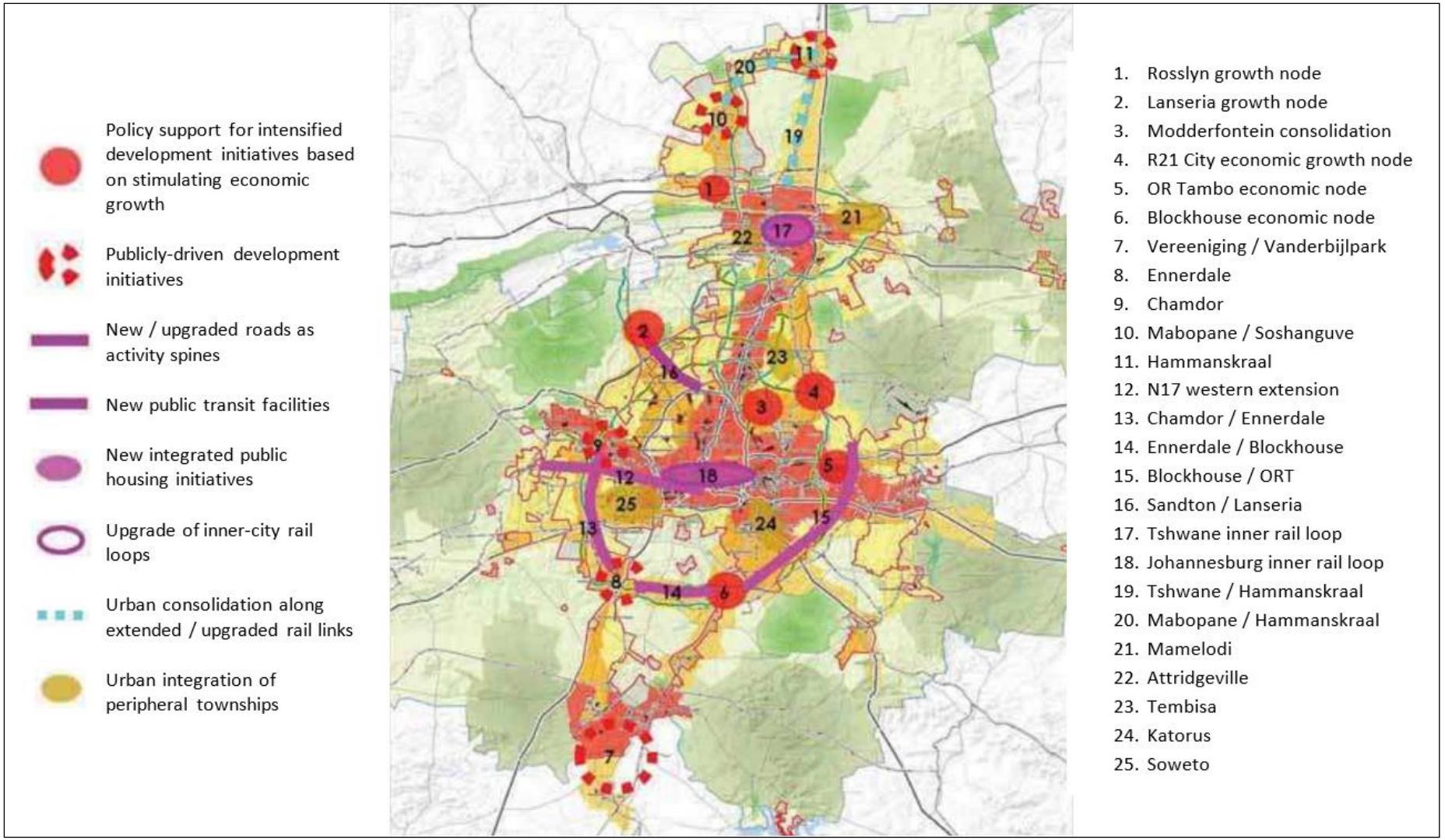


*Figure 2-3: Gauteng Province Urban Structuring Initiatives* Source: Gauteng Spatial Development Framework, 2011

## 2.3. Public Transport Supply in Gauteng

### 2.3.1. Existing Public Transport Supply in Gauteng

According to the National Household Travel Survey 2013 (NHTS 2013), 44% of Gauteng's commuters travel by private car and 43% travel by public transport, as presented in Table 2-1. A total of 12% of Gauteng's commuters walk all the way to their final destinations and 1% use other modes of transport (Department of Transport, 2013). In 2013, the Rapid Rail service carried 47 000 passengers on the Gautrain Passenger Service (GPS) on a typical weekday (Gautrain Management Agency, 2018). The Rapid Rail mode share in Gauteng was therefore less than 0.4% and was categorised as Other in the NHTS 2013 results.

*Table 2-1: Gauteng Commuter Mode Split*

| Mode | % of Gauteng Commuters |
|---|---|
| **Train** | 7% |
| **Bus** | 5% |
| **Minibus-taxi** | 31% |
| **Car** | 44% |
| **Walk all the way** | 12% |
| **Other** | 1% |

Gauteng's public transport is dominated by minibus-taxis, accounting for over 70% of all public transport use. The minibus-taxi services are privately run without government subsidy. The subsidised public transport services, namely bus and train, transport the remaining proportion of Gauteng's public transport commuters (McKay, et al., 2017).

The minibus-taxi services were first commissioned in the 1970's when there was a gap in the public transport supply market and a loop hole in the Road Transportation Act No 74 of 1977 (McKay, et al., 2017). The services have since been self-regulated by operating an unscheduled service with 15 to 20 seater vehicles on fixed routes. Although the routes are considered to be fixed, stops are not, thus the service operation is based on demand and allows passengers to board and align at any point along the route. The flexible boarding and alighting points are considered to be convenient for the passengers. As a result of public transport shortage in some areas and the convenience of the service, the minibus-taxi service quickly became the dominant mode of public transport within Gauteng.

Gauteng's passenger rail network was first introduced in Gauteng in 1890 (Metrorail, n.d.). The Metrorail service, now operated by the PRASA, follows the primary settlement axes, north-south between Tshwane and Vanderbijlpark / Vereeniging and east-west between Springs and Randfontein, as shown in Figure 2-4. The Metrorail service consists of 29 routes and over 200 stations and operates at an average speed between 35 and 45 km/h. The Metrorail frequency is route specific and ranges between two and five trains an hour during the peak periods.

South Africa's first rapid rail network was introduced in 2010 as an airport link between the OR Tambo International Airport and Sandton (Badenhorst, et al., 2014). The full commuter network was opened for operation in 2012. The Rapid Rail services are managed by the GMA and operated through concession contracts. The Rapid Rail network follows a north-south axis between Tshwane and Johannesburg and an east-west alignment between Sandton and the OR Tambo International Airport,

as shown in Figure 2-4. The Rapid Rail service consist of two routes and ten stations and operates at an average speed of 95 km/h. The Rapid Rail service runs six trains an hour during the peak periods.

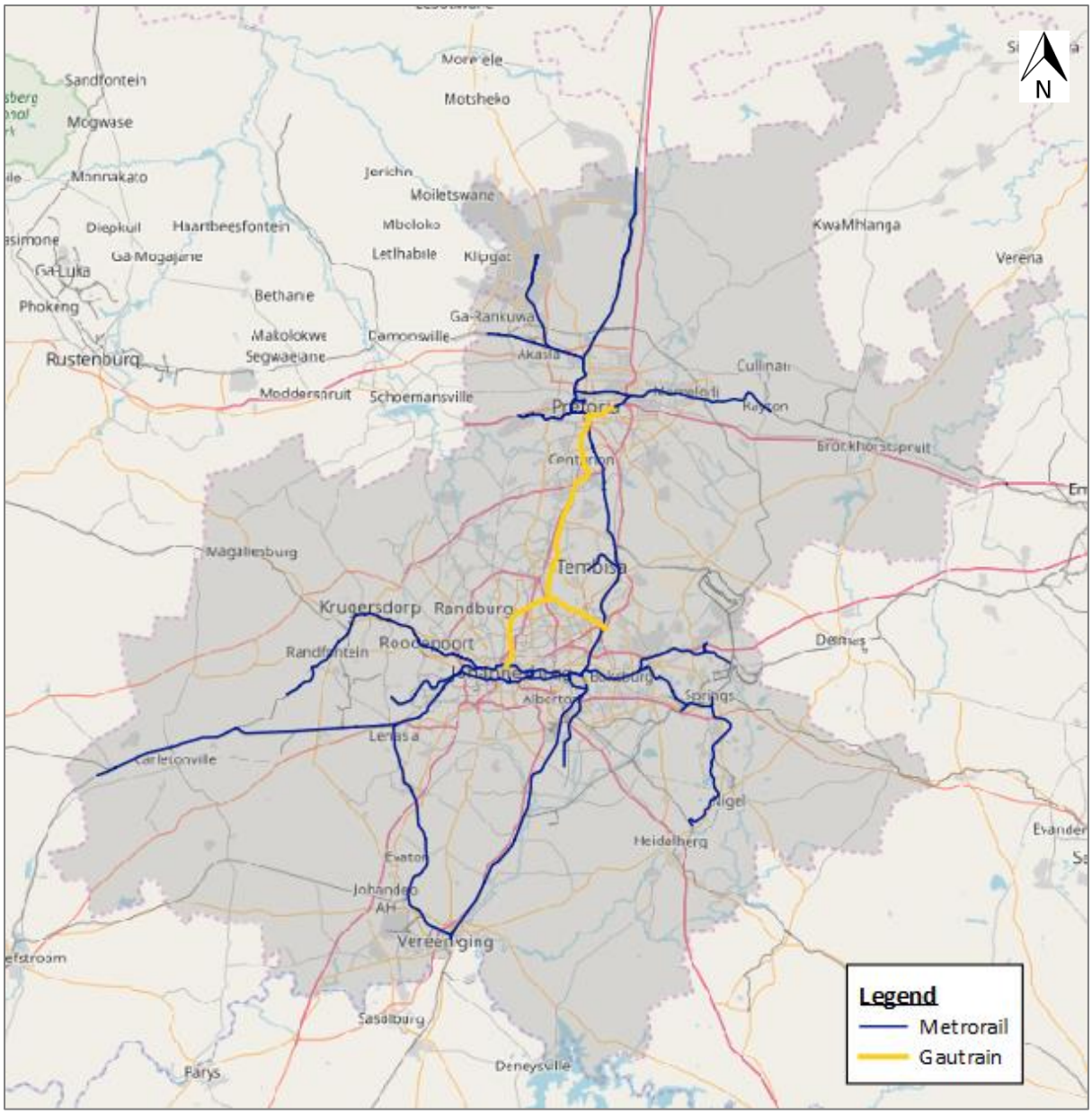


*Figure 2-4: Gauteng Passenger Rail Network*

The Metrorail patronage has declined over time, due to a deteriorating service and lack of investment into the system with 98% of the current rolling stock being older than 30 years (Badenhorst, et al., 2014). As a result, PRASA has developed the Modernisation program aiming to overhaul the Gauteng Metrorail services. The Modernisation program plans to update rolling stock, stations and the signalling system along the Metrorail network. Long term plans also include network extensions, as further discussed in Section 2.2.2.

The Rapid Rail service has experienced patronage growth beyond its forecasts. As a result, the GMA are in the process of designing the expansions of the Gauteng rapid rail network, by expanding the

existing Rapid Rail network towards the south-east of Tshwane and north-west to western region of Johannesburg (Gautrain Management Agency, 2017), as further discussed in Section 2.2.2.

### 2.3.2. Future Planned Public Transport Supply in Gauteng

The GITMP25 has been developed to map out the transport developments needed over the next 25 years. The GITMP25 was aligned with the GSDF 2011 and proposed the transport solutions necessary to support the future land use plans (Gauteng Province - Roads and Transport, 2013).

The GITMP25 discusses the importance of public transport mode hierarchy related to travel distance and passenger volumes. It is noted that the existing rail network coverage is sufficient and provides connectivity between the key nodes in Gauteng. However, the insufficient level of service on the existing Metrorail system is restraining the use and attractiveness of the service. The GITMP25 states that through modernisation of the existing Metrorail service, the Gauteng public transport hierarchy will be realigned, and rail will serve as the backbone of the transport system. The future planned rail network, as presented in Figure 2-5, focuses on a multi-tier rail network, comprising of Metrorail and Rapid Rail extensions. The new rail services proposed are presented in Table 2-2.

*Table 2-2: Proposed Rail Extensions in Gauteng Source: Gauteng Province - Roads and Transport, 2013*

| **Rail Type** | **Proposal** |
|---|---|
| **Rapid Rail** | • Mabopane – Pretoria – Germiston – Park – Naledi / Midway (upgrade - Modernisation)<br>• Mamelodi – Tshwane East – Samrand – Ruimsig – Roodepoort – Naledi (Soweto)<br>• Sandton – Ruimsig<br>• Rhodesfield – East Rand Mall - Boksburg<br>• Tshwane Ring Rail (upgrade) |
| **Commuter Rail (Metrorail)** | • Hammanskraal – Pretoria (upgrade)<br>• Leralla (Tembisa) – Midrand<br>• Mamelodi – Pienaarspoort – Rayton / Bronkhorstspruit (upgrade)<br>• Daveyton – Etwatwa<br>• Baralink<br>• Moloto – Pretoria |

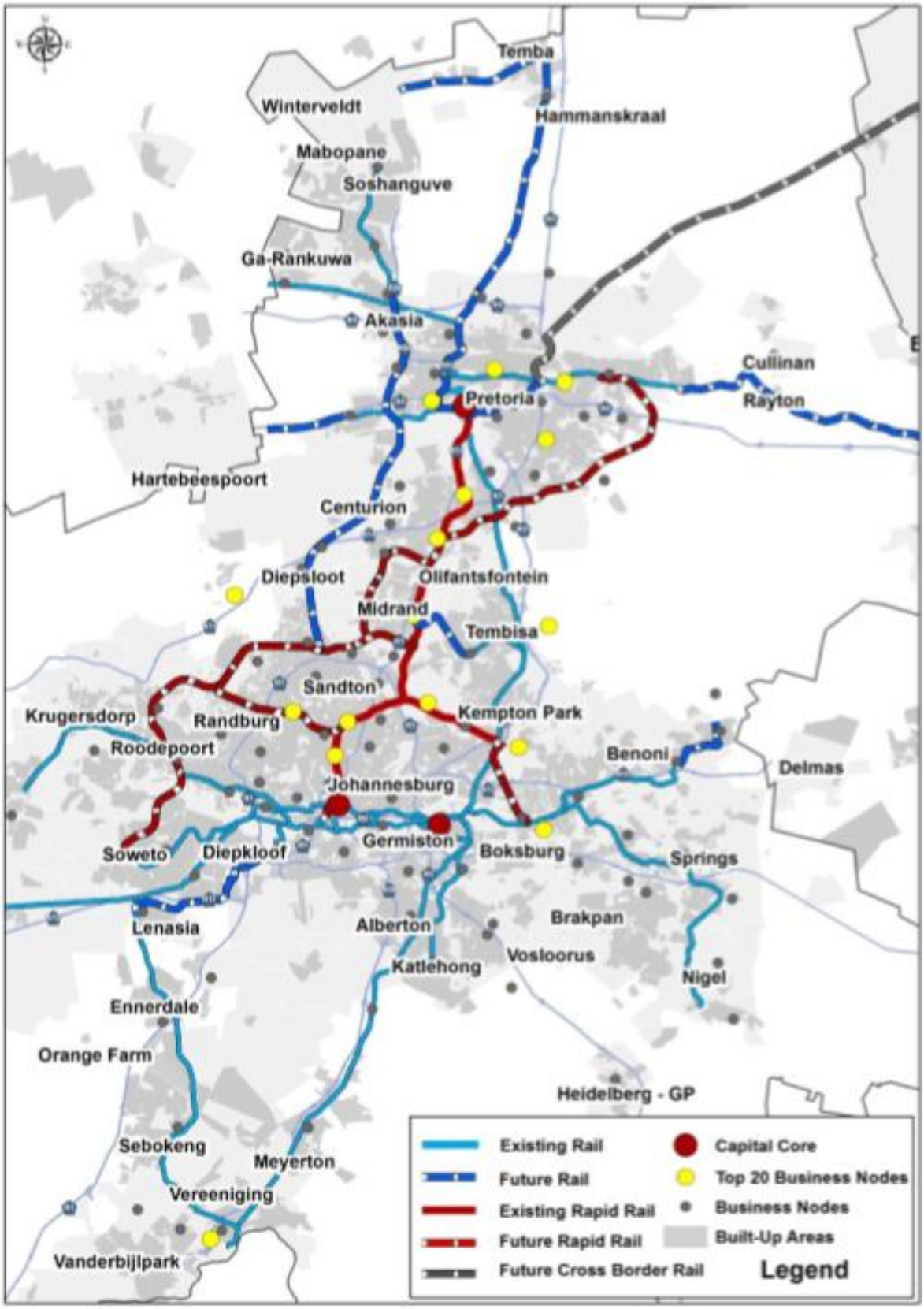


*Figure 2-5: Proposed Future Rail Network in Gauteng Source: Gauteng Province - Roads and Transport, 2013*

## 2.4. Travel Behaviour in Gauteng

The travel behaviour, particularly mode choice, in Gauteng has changed significantly over time. Although the proportion of private vehicle users has stayed consistent between 41 – 49%, a significant change in mode choice between the available modes of public transport has been observed, as shown in Table 2-3. From the 1970's to early 2000's users of the subsidised modes of public transport, namely bus and rail, have shifted to the privately owned minibus-taxi public transport system. As discussed by Badenhorst, et al, the dominant reason for this mode shift is considered to be due to the deterioration of service quality and lack of maintenance of these publicly owned services.

*Table 2-3: Mode Split of Transport to Work in Gauteng* Source: Badenhorst, et al., 2014

| | | Walk | Metrorail | Minibus-Taxi | Bus | Private Vehicle |
|---|---|---|---|---|---|---|
| **1975** | Pretoria-Witwatersrand-Vereeniging (PWV) Transport Survey | 7% | 20% | 3% | 21% | 49% |
| **1999/2003** | 1998/99 Tshwane Survey and 2002/03 Gauteng Transport Survey for the GTS 2000 Survey | 9% | 6% | 31% | 6% | 48% |
| **2003** | National Household Travel Survey | 11% | 9% | 31% | 6% | 43% |
| **2009** | GCRO's Quality of Life (QoL) Survey | 10% | 4% | 41% | 4% | 41% |
| **2011** | GCRO's QoL Survey | 6% | 5% | 42% | 3% | 44% |
| **2013** | National Household Travel Survey | 13% | 7% | 31% | 5% | 44% |

The current mode choice by income in Gauteng is presented in Table 2-4, in terms of the following income categories:

- Low income: R0 – R3 200;
- Middle income: R3 200 – R12 800; and
- High income: > R12 800.

According to the 2009 Quality of Life survey, although minibus-taxi is the dominant mode choice, the rail usage is double that of the bus usages within the low income Gauteng population (Badenhorst, et al., 2014). The opposite is observed for the middle income population, where the bus usage is more than double that of the rail usage. The change in private vehicle use between low income (6%) and middle income (58%) is significant. The high income population does not consider Metrorail as a choice of travel, and are largely reliant on private vehicle transportation.

*Table 2-4: Mode Choice by Income in Gauteng* Source: Badenhorst, et al., 2014

| | Metrorail | Minibus-Taxi | Bus | Private Vehicle |
|---|---|---|---|---|
| **Low Income** | 6% | 85% | 3% | 6% |
| **Middle Income** | 2% | 35% | 5% | 58% |
| **High Income** | 0% | 15% | 2% | 83% |

Mode choice in Gauteng is largely driven by the availability of the various modes of transport between the place of residence and place of work. Figure 2-6 demonstrates Badenhorst's, et al, analysis of the level of accessibility to work from various townships in Gauteng. The analysis considered accessibility to minibus-taxi and rail services. The access index plots standardised indices, considering the proximity of the townships to employment nodes (the absolute value indicating a standardised distance) and the level of service and availability of public transport (mini-bus taxi and rail) where positive represents good level of service /availability and negative indicated poor level of service /availability.

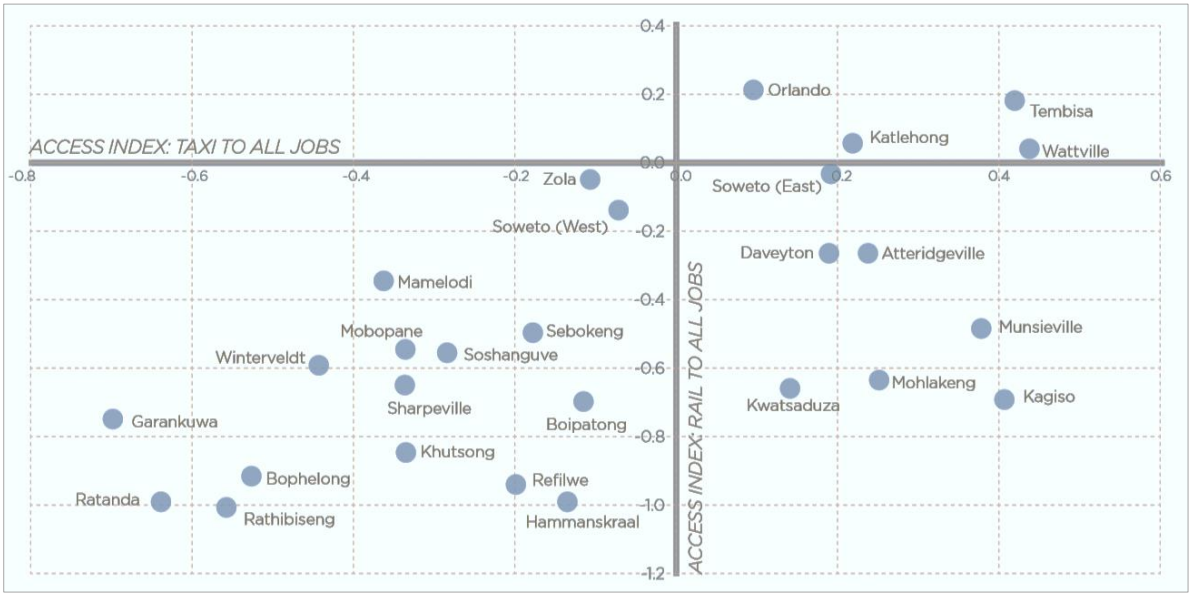


*Figure 2-6: Standardised Minibus-taxi and Rail Access Indices Source: Badenhorst, et al., 2014*

Only 15% of the townships investigated were considered to have good public transport access to both minibus-taxi and rail services. A total of 31% of townships were considered to have good accessibility to at least minibus-taxi services. Bardenhorst, et al, further investigated the reason for people not using public transport in Gauteng, as presented in Table 2-5. The analysis considered the results in terms of income groups as follows:

- Low income: R0 – R3 200;
- Middle income: R3 200 – R12 800; and
- High income: > R12 800.

The main reasons for not using public transport differs substantially between the different income groups. Low income groups' reasons for not using public transport is mainly due to affordibility and lack of accessibility. Middle income groups tend to not use public transport if they are able to afford a private vehicle. High income groups' reasons for not using public transport include the ability to afford a private vehilce, the convenience of travelling by a private vehicle and safety and security concerns of the public transport services. Many responses across all income groups simply stated that they do not want to use public transport, thus prefer to use other means of travel.

*Table 2-5: Reasons for Not Using Public Transport* Source: Badenhorst, et al., 2014

| | Public transport access problems | | | Public transport cost | Public transport safety problems | | Non-motorised transport (NMT) user | Public transport non-user | Car preference/utility | | | | | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly household income | No public transport services in my area | It takes too long to walk to nearest stop/station | The wait for public transport is too long | I can't afford public transport | I worry about crime/ safety | I worry about road/rail accidents | I walk/cycle | I don't want to use public transport | I can afford a car | I get to work/school on time with my car | I can take unplanned trips | I drop off friends/family on my way – better than everyone using public transport | I am a member of a lift club/passenger | Other |
| Zero to R400 | 14% | 4% | 7% | 27% | 5% | 2% | 6% | 14% | 5% | 1% | 2% | 0% | 2% | 11% |
| R401-R3 200 | 15% | 12% | 6% | 10% | 4% | 3% | 6% | 13% | 8% | 2% | 5% | 1% | 1% | 16% |
| R3 200-R12 800 | 14% | 7% | 3% | 4% | 5% | 3% | 2% | 16% | 18% | 9% | 10% | 1% | 0% | 7% |
| R12 801-R102 400 | 8% | 4% | 3% | 1% | 5% | 2% | 1% | 20% | 28% | 14% | 12% | 1% | 0% | 2% |
| R102 400 + | 4% | 8% | 2% | 0% | 17% | 3% | 0% | 10% | 18% | 4% | 19% | 4% | 0% | 10% |
| Response not given | 8% | 6% | 5% | 2% | 6% | 1% | 3% | 23% | 12% | 6% | 11% | 1% | 0% | 15% |
| ALL | 10% | 6% | 5% | 5% | 6% | 2% | 3% | 19% | 15% | 7% | 10% | 1% | 1% | 11% |

## 2.5. Driving Factors Influencing Mode Choice

Mode choice modelling aims to capture the complex influences of decision making and express it in a mathematical context. The influences range from being quantitative (i.e. measurable) to qualitative, which are more difficult to capture in a mathematical context. All these influences are considered in mode choice modelling and are typically calibrated to the travel behaviour in a local context.

### 2.5.1. Mode Choice Theory

Mode choice modelling considers the theory of random utility maximisation and is presented in terms of a mathematical based logit model (Khan, et al., 2007).

The utility function is typically a linear function considering attributes which are related to a journey travelled between a point A and a point B. These attributes, which are further discussed in Chapter 2.4.2, are weighted within the utility function by means of utility coefficients. The weightings are used to distinguish the relative importance of one attribute over another. The utility function is given as follows:

$$U_m = C_m + \beta_1 \times X_1 + \beta_2 \times X_2 + \ldots\ldots + \beta_i \times X_i + \mathcal{E}_m$$

Where:

$U_m$ – utility function for mode m

$C_m$ – mode constant for mode m

X – utility attribute linked to choice

B – utility coefficient associated with its specific attribute

$\mathcal{E}$ – Error term

Mode constants and utility coefficients are typically derived by means of stated or revealed preference surveys in order to introduce the study area travel behaviour into the mathematically derived utility function.

The probability of an individual choosing a mode (m) within the mode choice model is determined by means of a probability function, which considers the estimated utility function discussed above. The probability function is given as follows:

$$P_m = \frac{\exp(U_m)}{\sum_{n \varepsilon S} \exp(U_n)}$$

Where:

$P_m$ – probability of mode m being chosen

$U_m$ – utility of the mode m under consideration

$U_n$ – utility of a mode forming a part of the set of available modes

S - set of all available modes of travel

Mode choice modelling rank ordered choice sets could also be used to estimate the mode choice parameters (Chapman & Staelin, 1982). The derivation of rank ordered choice sets and its application is further discussed in Chapter 2.6.

### 2.5.2. Mode Choice Modelling Attributes

Mode choice is driven by the various options presented for travelling by two or more modes of transport. Each available mode of transport consists of travelling attributes, linked specifically to that mode. Mode choice modelling is therefore driven by the reason a traveller chooses one mode over another. The decision making process is driven by a number of steps and questions, such as the reason for travelling, availability for travelling and attribute comparison of available modes (Rahman, 2017). Once these steps are considered, a mode choice can be made, or in some cases a choice of travelling can be made.

Mode choice is also dependent on the socio-economic situation of the traveller. For example, a high income business person's decision making drivers would differ from that of a low income person seeking work. Travel behaviour and mode choice is therefore modelled in terms of trip purpose by socio-economic status. Key mode choice attributes, as discussed by Khan, et al, are presented in Table 2-6.

*Table 2-6: Mode Choice Modelling Attributes* Source: Khan, et al., 2007

| **Attributes** |
|---|
| **General** |
| Mode constant |
| **Travel Characteristics** |
| In-vehicle Travel Time (IVT) |
| Travel Cost |
| Parking Cost |
| Combined walk access and egress time to / from the public transport station |
| Waiting Time |
| **Household Characteristics** |
| Persons per household |
| Adults per household |
| White collar workers per household |
| Blue collar workers per household |
| Licence Holders per household |
| Tertiary Students per household |
| School Students per household |
| Vehicles per household |
| **Employment Characteristics** |
| Employment density |
| Retail Employment density |

### 2.5.3. Perceived Quality of Service

Mode choice drivers, as discussed in Section 2.5.2, are related to the travel mode services at a particular point in time. The quality of service received by the passenger, at a specific point in time, therefore depicts the service's perceived quality for that time. Should the quality of the service change overtime, and this change is experienced by the passenger, their perception of the service's quality will change. Considering this trend, public transport service providers have started paying closer

attention to the customer satisfaction and how the quality of their services are being perceived by the passengers (Barabino, Deinna, & Tilocca, 2011). The planning and designing of public transport services have therefore started focusing on passenger experience with the aim to trigger patronage growth and loyalty towards the service (Cunningham, Christensen, Dunn, Gonzales, & Hirsch, 1996). In order for this to be successful, it is key to identify the drivers behind mode choice, for both existing and potentially new passengers, and particularly those mode choice drivers attributed to the service's perceived quality. It has been evident, in the transportation sector, that a positive perception of public transport could lead to a mode shift from car to public transport (Barabino, Deinna, & Tilocca, 2011). It has also been found that the perception of service quality is closely linked to the loyalty a passenger holds towards the service or travel mode. If a passenger is happy with the service they are being provided, they are unlikely to switch to a different mode. Therefore, if the passengers on a service are happy and remain to be happy, the service will retain its demand. The perceived service quality has also been linked to operational attributes, such as service punctuality, reliability and the quality of service information provided (Konig, 2002). Furthermore, if the service quality is aligned with the expectations of travellers, the service attractiveness improves and public transport usage could increase (Beirao & Sarsfield Cabral, 2007). However, the relationship between service quality and passenger satisfaction does have a tipping point, where a service which has exceptionally high quality attracts passengers with high standards and expectations and are easily dissatisfied over the slightest imperfections in service (Barabino, Deinna, & Tilocca, 2011). It should also be noted, that mode choice impacted by service quality are relevant to choice users, whereas captive users would be unable to make a mode shift, irrespective of the quality of service.

### 2.5.4. Habitual Mode Choice Behaviour

One of the initiatives to reduce road congestion in cities is to promote the use of public transport. The mode switch from private vehicles to public transport increases vehicle occupancy, and in return reduces the number of vehicles on the road. Chen & Chao (2011) investigated habitual mode choice behaviour and how this can be used to attract private vehicle users to use public transport. The use of private vehicles is perceived to be convenient, comfortable and often faster than public transport. A habit develops through the frequent use of a particular mode, and in the case of private vehicle usage, this habit forms a link between a travelling goal (e.g. travelling to work) and travelling behaviour (mode choice) (Chen & Chao, 2011). A strong private vehicle usage habit develops when the user does not experience any significant short comings in their mode choice and their travelling goals are consistently met through their mode choice. For example, when someone is travelling from home to work by private vehicle every day, and does not experience significant delay or high travel costs along the route, their travel needs are being met satisfactorily by the private vehicle mode choice and they will develop a strong private vehicle habit. In contract, if a traveller is travelling into a congested city by private vehicle every day, subjected to high travel costs in terms of toll and parking, while there is a possible alternative to use the rail mode, they would develop a weak private vehicle habit. It is more difficult to break a strong private vehicle habit as compared to a weak private vehicle habit. In the case of a weak private vehicle habit, the traveller would consider many different travel circumstances or modes before making a decision. Thus, through the consideration of the various options, the traveller could easily break the private vehicle habit. A traveller with a strong private vehicle habit would consider far less options, and in some cases only one option (i.e. the private vehicle). It therefore makes it difficult to convince a traveller with a strong private vehicle habit to consider any other travel options (Aarts, Verplanken, & van Knippenberg, 1997).

### 2.5.5. South African Context

In 2012 the Institute of Transport and Logistics Studies (ITLS) conducted a survey known as the State of Transport Opinions Poll South Africa (STOPSA). The survey results indicated that transport is considered the third highest national priority, as shown in Table 2-7, after education and health. The dominant issue related to transport is public transport, as shown in Figure 2-7. The survey results indicate that respondents are concerned over the following aspects related to public transport:

- Service coverage;
- Safety and reliability;
- Mobility and accessibility;
- Affordability; and
- Quality.

*Table 2-7: National Priority Rating* Source: Heyns & Luke, 2013

| High Priority Issues | Rating (out of 100) | Ranking |
|---|---|---|
| **Education** | 66 | 1 |
| **Health** | 61 | 2 |
| **Transport** | 61 | 3 |
| **Social Issues** | 61 | 4 |
| **Environment** | 61 | 5 |
| **Economy** | 58 | 6 |
| **Law and Order** | 57 | 7 |
| **Safety and Security** | 57 | 8 |
| **Housing** | 55 | 9 |
| **Infrastructure** | 54 | 10 |
| **Employment** | 43 | 11 |

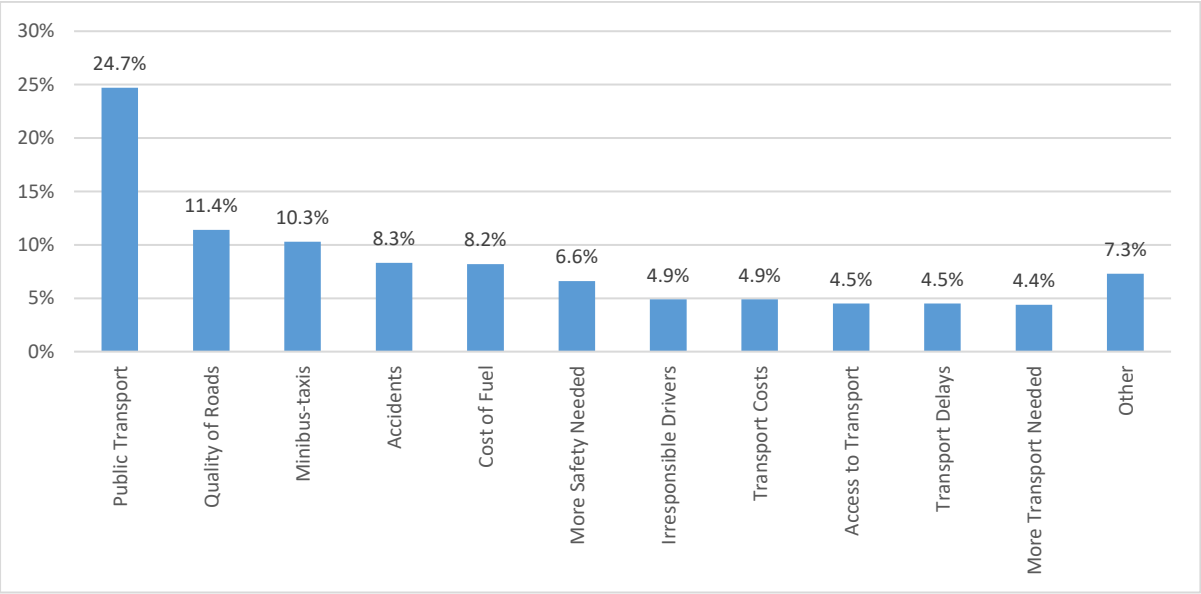


*Figure 2-7: Transport Issues Source: Heyns & Luke, 2013*

The STOPSA results indicated that South African mode choice is predominantly, apart from affordability, driven by qualitative measures, leading to emotional decision making.

Van Zyl & Venter evaluated the quantitative measures driving mode choice through a case study in Johannesburg, Gauteng. The case study evaluated the mode choice parameters from stated preference data to establish the driving factors of mode choice between private vehicles and buses. The parameters considered in van Zyl & Venter's evaluation are presented in Table 2-8. The quantitative parameters are aligned with the travel characteristics and the qualitative parameters were aligned with the general mode constant as discussed in Chapter 2.4.1.

*Table 2-8: Stated Preference Case Study Mode Choice Parameters* Source: van Zyl & Venter, 2009

| Parameter | Units | Nature of Parameter |
|---|---|---|
| **Private Vehicle** | | |
| In-vehicle Time | Minutes | Quantitative |
| Parking Cost | Rands per day | Quantitative |
| Fuel Cost | Rands per trip | Quantitative |
| **Bus** | | |
| Wait Time | Minutes | Quantitative |
| Walk Time | Minutes | Quantitative |
| In-vehicle Time | Minutes | Quantitative |
| Fare | Rands per trip | Quantitative |
| Experience | Constant | Qualitative |
| **Income** | Rands | Quantitative |
| **Inertia to Change** | Constant | Qualitative |

Statistics South Africa conducted research on gender differences in travel, through considering travel patterns and mode choice drivers (Statistics South Africa, 2016). The research utilised the following data sources:

- NHTS 2013
- 2016 Community Survey; and
- 2015 General Household Survey (GHS).

The Statistics South Africa research considered survey data across South Africa and concluded that for both male and female respondents, the main reasons for mode choice is travel time and travel cost, as presented in Table 2-9.

*Table 2-9: Mode Choice Drivers to Place of Employment by Gender Source: Statistics South Africa, 2013*

| Reason for Selecting Transport Mode | Male Respondents | Female Respondents |
|---|---|---|
| Travel time | 32.6% | 32.2% |
| Travel cost | 24.6% | 24.0% |
| Flexibility (travel wherever, whenever you want) | 10.4% | 10.9% |
| Safety from accidents | 9.0% | 8.8% |
| Comfort | 5.8% | 6.0% |
| Reliability | 4.9% | 5.3% |
| Distance from home to transport / accessibility | 3.5% | 3.5% |
| Drivers' attitude | 3.1% | 3.2% |
| Other | 2.9% | 2.8% |
| Security from crime | 2.6% | 2.5% |
| Inaccurate transport timetable information | 0.6% | 0.6% |

## 2.6. Multi-criteria Decision Making and Ranking

Multi-criteria decision making, also known as MCA, is a decision making methodology which considers multiple, and sometimes conflicting, criteria and finds a solution which most satisfies the needs of the problem at hand (Scott, et al., 2012). The MCA consists of two elements, namely the ranking and weighting of criterion.

The ranking of criterion describes the relative importance between the criteria being considered in the MCA. Ranking is generally defined as being sequential with the most and least important criterion being ranked on opposite ends of the ranking order. Ranking is considered to be the simpler process of the MCA, as it only considers one element, the level of importance. Typically, decision makers are more confident to define the ranks of criteria rather than their weights, as the agreement of ranks are made easier than weights (Roszkowska, 2013).

An MCA typically consists of numerous criteria which vary in their degree of impact on the decision making. In order to define this degree of impact, weightings are assigned to each criterion. The point-method is an MCA method used to compare the criterion with one another in the form of weightings (Jacyna & Warsiak, 2015).

The point-method defines the set of criteria to be used in the evaluation of possible solutions and assigns a weight to each criterion. These weights are aligned with the relative level of importance of each criterion and belongs to the range [0, 1]. It is also important to ensure that the sum of all the weights is equal to 1 (Jacyna & Warsiak, 2015). Finally, the weights are applied to each criterion and solutions' ranking is based on maximising the product of the criterion score and its associated weighting.

Various techniques can be used to derive the ranked weights, as elaborated by Roszkowska. The decision of which technique to use is reliant on the available information around the criteria. The equal

weight method requires the least information about the relative weights of the criteria. If no information is known about the true weights of each criterion, the equal weight method could be applied which assumes a uniform provability density function. The rank sum weight method links the criterion weight to the ranking, thus the weighting is normalised through the sum of the rankings. The rank exponent weight method is a generalised form of the rank sun weight method, with variability in the weight distribution, through an exponential parameter. This method becomes applicable if information on the relativity of criterion weights is known (Roszkowska, 2013).

As with all solution evaluation methodologies, the MCA has its own set of strengths and weaknesses. Prosser, et al highlights that the MCA's biggest strength is its flexibility in evaluation. The MCA is able to be applied to high level strategic evaluations through to detailed project evaluations. The MCA is also able to easily handle non-quantifiable criteria, such as social impacts and policies, which cannot be easily dealt with in more traditional evaluation methods such as Benefit Cost Analyses (BCA) (Prosser, et al., 2015).

Prosser, et al also highlights some of the shortcomings of the MCA, including the possible overlap of benefits between multiple criteria, which could lead to double counting in the evaluation. The MCA could also be considered to be too subjective, particularly when determining the weights to be applied to each criterion. The method has been criticised whereby the evaluation steps are not transparent enough and logical steps leading to final evaluation outcome may not be clear (Prosser, et al., 2015).

# 3. STUDY AREA

This chapter details the study area considered for this research study and describes the data collection process followed to obtain the inputs required for the analyses.

## 3.1. Geography and Demographics

The Gauteng Province was chosen as the study area for this research study. As presented in Figure 3-1, the Gauteng Province is located in the central region of South Africa. Gauteng is South Africa's smallest province, covering a total of 18 178 $km^2$ and has the largest population, totalling 12 272 263 (Lehohla, 2014). Gauteng Province is made up of five District Municipalities, as shown in Figure 3-2. A total of 86% of the Province's population is concentrated in the three Metropolitan cities of Johannesburg, Ekurhuleni and Tshwane, as presented in Table 3-1. These Metropolitan cities fall within the urban fringe of the Gauteng Province, while Sedibeng and West Rand District Municipalities consist of rural land use activities, including agriculture. According to the GSDF 2011, the future urban planning is to stay concentrated within the existing urban fringe. This concentration will ensure that the urban population is serviced with adequate services, including transportation.

*Table 3-1: Gauteng District Municipality Population Source: (Lehohla, 2014)*

| District Municipality | Population |
|---|---|
| **City of Johannesburg** | 4 434 826 |
| **City of Tshwane** | 2 921 488 |
| **Ekurhuleni** | 3 178 470 |
| **Sedibeng** | 916 484 |
| **West Rand** | 820 995 |
| **Total** | 12 272 263 |

The Gauteng population density is concentrated within the three metropolitan municipalities as shown in Figure 3-3. The historic settlement patterns discussed in Chapter 2.1 are still evident today with a dominant north-south and east-east densified settlement pattern observed, with pockets of densely populated areas located outside of these axes, formed as a result of the apartheid planning.

Gauteng's job density is concentrated around the core economic nodes, including Johannesburg CBD, Sandton, Boksburg, Kempton Park and Tshwane CBD, as shown in Figure 3-4. A decentralised economic node is also present in the south of Gauteng, in Vereeniging. Figure 3-3 and Figure 3-4 illustrate that the population settlements are sparsely located compared to the job density. This settlement pattern therefore results in long commuting distances.

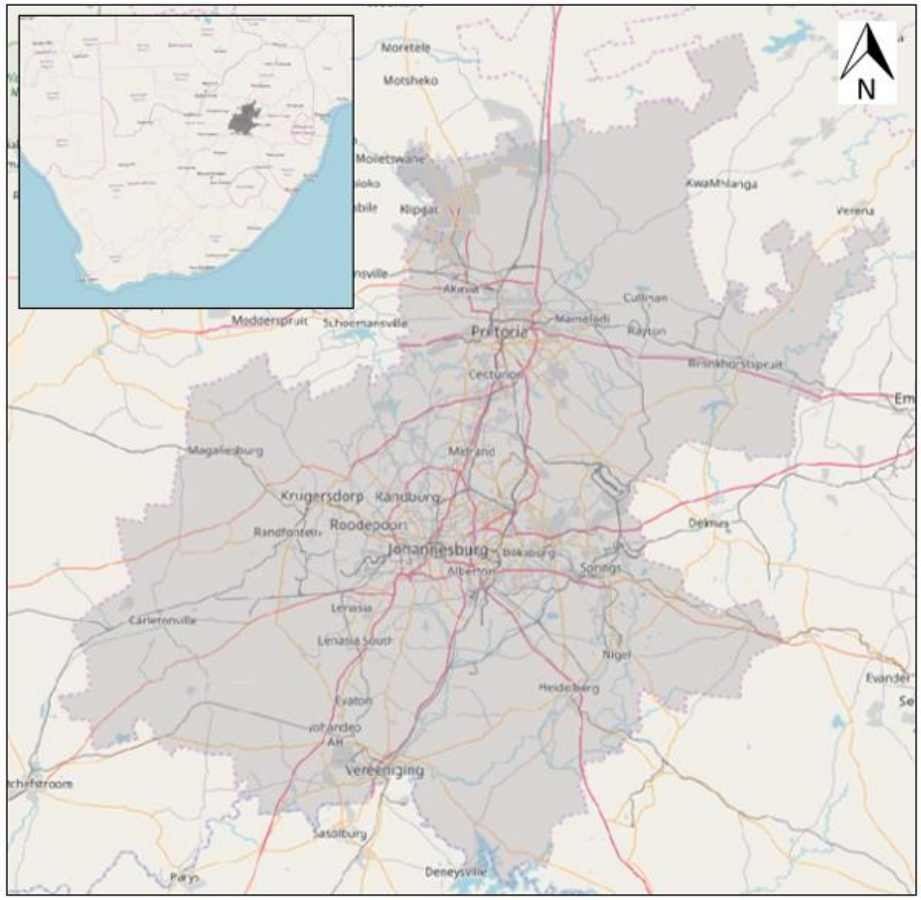


*Figure 3-1: Study Area*

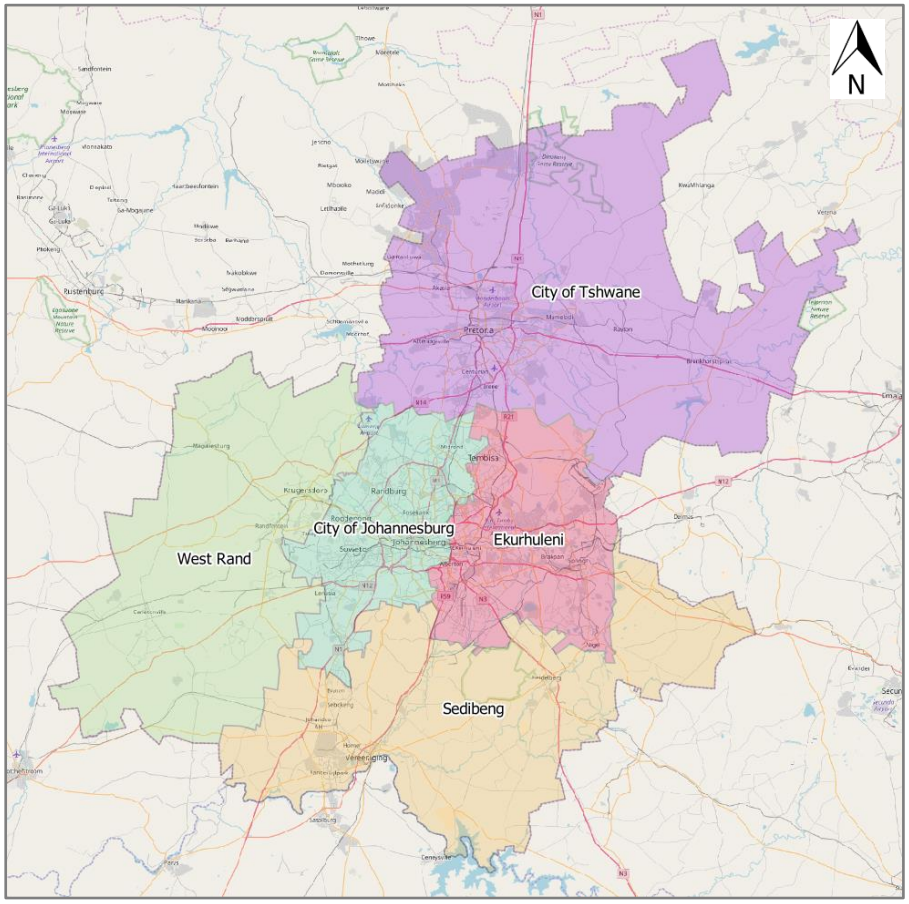


*Figure 3-2: Gauteng District Municipalities*

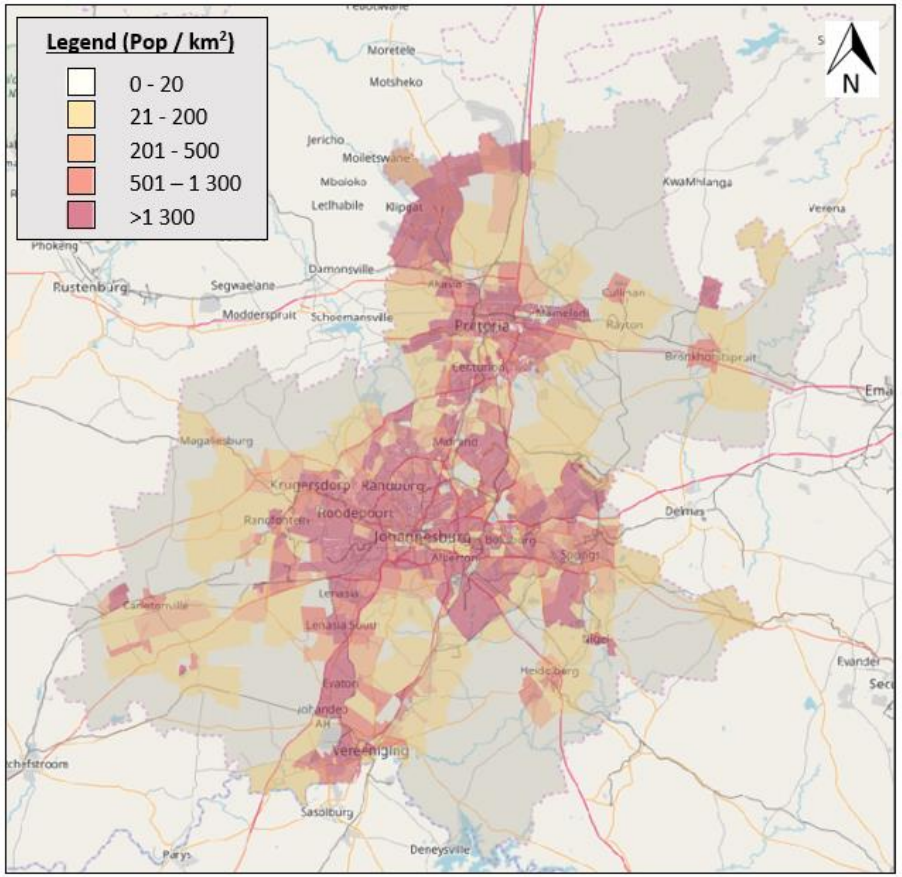


*Figure 3-3: Gauteng Population Density*

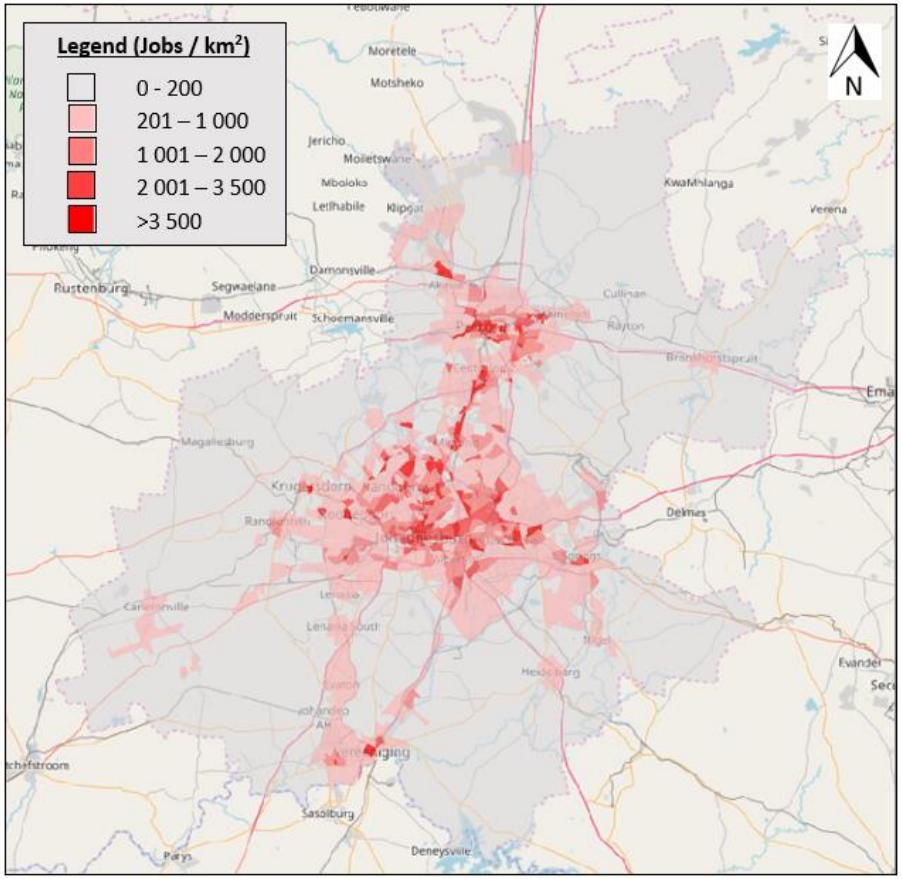


*Figure 3-4: Gauteng Employment Density*

## 3.2. Rail Services

The Gauteng existing rail network is presented in Figure 3-5. The Gauteng Province is currently the only province in South Africa which is serviced by two rail services, namely Metrorail and Rapid Rail. The Metrorail service is operated by PRASA and the Rapid Rail service is operated by the GMA.

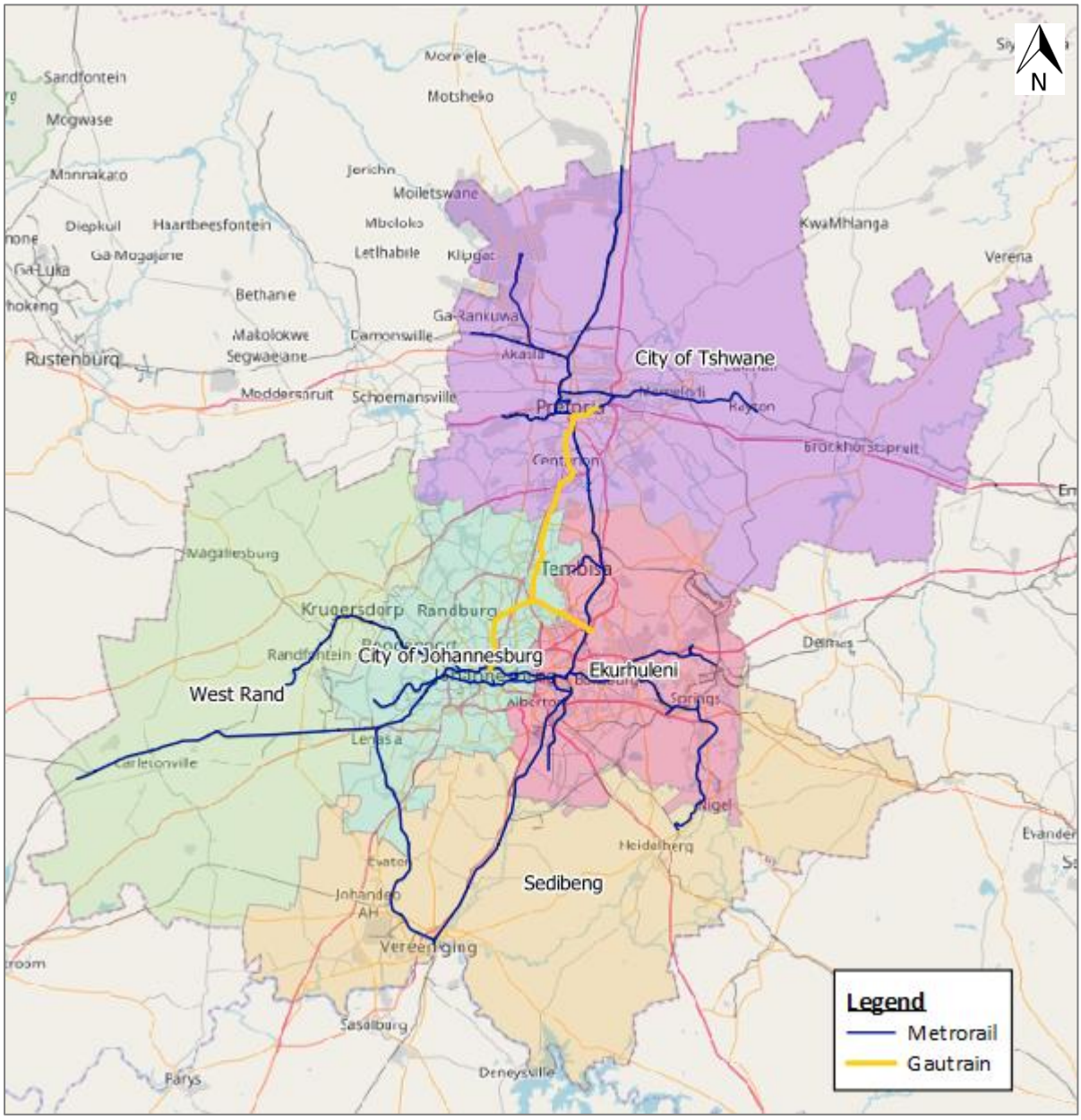


*Figure 3-5: Gauteng Province Rail Networks*

The Metrorail service operates in all five District Municipalities, with a concentration of services within the urban areas. The Gauteng Metrorail alignment consists of over 200 stations and 11 service lines. The Metrorail services' timetable is defined for weekdays, Saturdays and Sundays. Weekday services are scheduled around commuter trips and start as early as 02:50 in the morning between Vereeniging and Johannesburg (Metrorail, 2019). The Metrorail services operate with average speeds of 45 km/h. Express services exist between Pretoria and Johannesburg (eight in the morning peak period) and Vereeniging and Johannesburg (three in the morning peak period) and operate at average speeds of 61km/h and 52km/h respectively. The express services stop at a limited number of stations between

the origin station and destination station resulting in an increase travel speed. The reliability of the Gauteng Metrorail services is reported on a monthly basis in terms of a punctuality index. The punctuality of services is derived by considering the total number of services scheduled, cancelled and delayed and calculating the proportion of services which arrived as scheduled. The Gauteng Metrorail punctuality target is 90%. The actual punctuality achieved by the Gauteng Metrorail services between 2012 and 2017 is presented in Table 3-2. PRASA's train performance reports indicated that the Gauteng Metrorail services have not met the punctuality targets between 2012 and 2017. On average 6% of services are cancelled and 16% of services are delayed.

*Table 3-2: Gauteng Metrorail Punctuality Index Source: (PRASA, 2017)*

| Period | Punctuality | Target |
|---|---|---|
| **2012/2013** | 75% | 90% |
| **2013/2014** | 80% | 90% |
| **2014/2015** | 82% | 90% |
| **2015/2016** | 79% | 90% |
| **2016/2017** | 76% | 90% |

The latest published Gauteng Metrorail fares are based on a 2014 distance zonal structure, with fares defined for the following trip lengths:

- 0 – 10km
- 11 – 19km
- 20 – 30k
- 31 – 50km
- 51 – 100km
- > 100km

The Gauteng Metrorail fare structure was estimated as a kilometre based fare in order to be directly comparable with the Rapid Rail fare structure. The kilometre-based function, which best fit the distance zonal structure, was R5.00 + R0.11 per kilometre (based on the published 2014 fare structure).

The Rapid Rail services operate in the three Metropolitan Districts and consists of 10 stations and two commuter service lines and an airport line. The Rapid Rail services' timetable is defined for weekdays, weekends and public holidays. Weekday services are scheduled around commuter trips and start at 05:26 in the morning between Hatfield and Johannesburg and 04:50 between Sandton and the OR Tambo International airport (Gautrain Management Agency, 2019). The Rapid Rail services operate with average speeds of 95 km/h. The reliability of the Rapid Rail services is reported on a monthly basis in terms of a punctuality index and published in the GMA Annual Reports (Gautrain Management Agency, 2018). The Rapid Rail punctuality target is 94%. The actual punctuality achieved by the Rapid Rail services between 2012 and 2018 is presented in Table 3-3. The GMA's Annual Reports indicated that the Rapid Rail services have exceeded the punctuality targets between 2012 and 2018.

*Table 3-3: Rapid Rail Punctuality Index Source: (Gautrain Management Agency, 2018)*

| Period | Punctuality | Target |
|---|---|---|
| **2012/2013** | 98% | 94% |
| **2013/2014** | 97% | 94% |
| **2014/2015** | 97% | 94% |
| **2015/2016** | 99% | 94% |
| **2016/2017** | 98% | 94% |
| **2017/2018** | 99% | 94% |

The Rapid Rail fare structure is based on an origin-destination station fare structure. In order to be directly comparable with the Gauteng Metrorail fare structure, the 2014 Rapid Rail fares were used to derive a kilometre-based fare function. A regression analysis between the trip costs and distances between each station was used to derive the best fit linear Rapid Rail fare function, and resulted in a fare function of R17.77 + R0.77 per kilometre. The Rapid Rail system is supported by an integrated public transport system, considering distribution and feeder bus routes linking each station to the surrounding catchment of approximately 5km. The Rapid Rail stations also consist of park-and-ride facilities, providing passengers with the option of travelling to the with their car, parking their vehicle at a safe location for the day's duration and continuing their trip by Rapid Rail. The park-and-ride facilities are well utilised, with more than 40% of Rapid Rail passengers indicating that they accessed their origin station via the Gautrain park-and-ride facilities (Gautrain Management Agency, 2018).

# 4. RESEARCH METHODOLOGY

This research study aims to understand the current rail commuter markets within the Gauteng Province and investigate whether a competitive rail market overlap could occur as a result of PRASA's Modernisation program. This chapter describes the methodology used in this research study to meet the study objectives. The study's phased approach is presented in Figure 4-1.

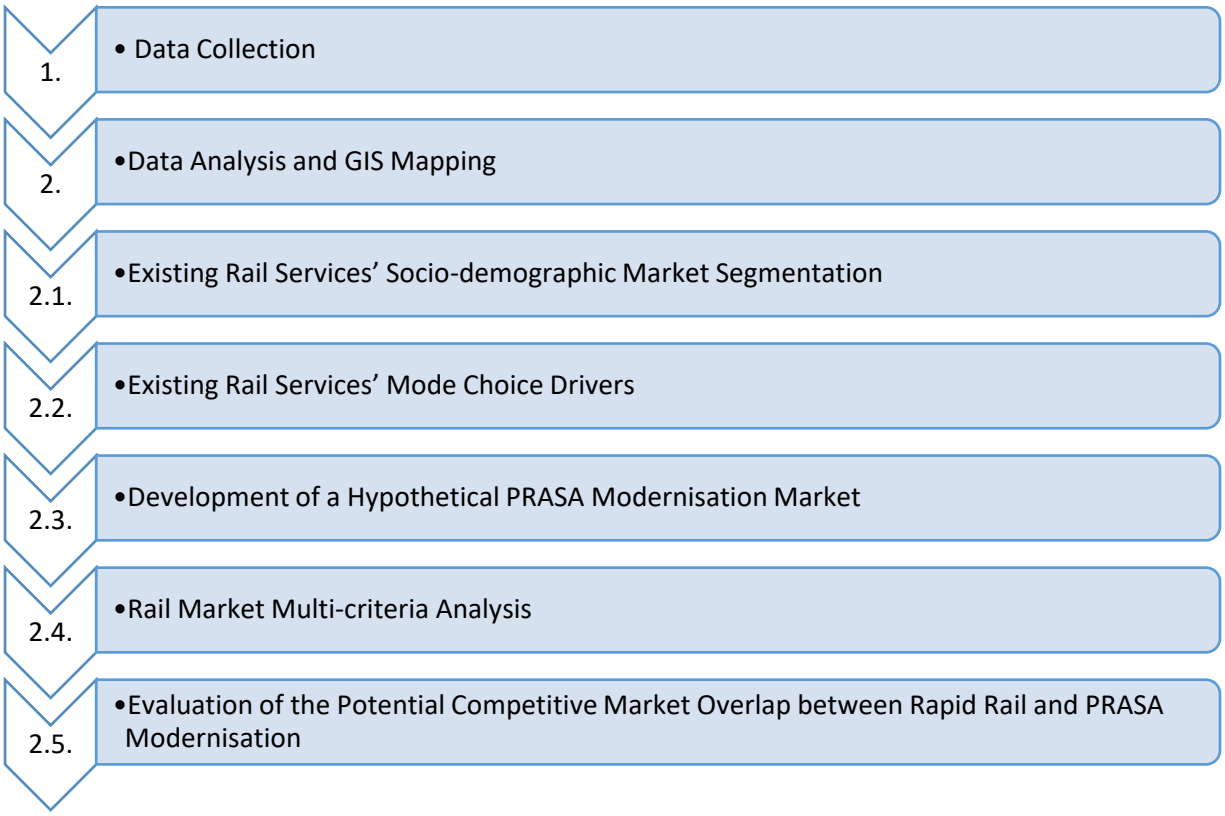


*Figure 4-1: Research Design*

The research methodology consisted of a geographical analysis, which evaluated the locality and density of the Gauteng Province's socio-demographics. The geographical analysis also assessed the locality and influence areas of the rail services within the study area. Thereafter rail passenger surveys were used to derive the passengers' socio-demographic market segmentation and mode choice drivers of the existing rail services within the study area. The market segmentation was aligned with the Census 2011 socio-demographic definitions and household income was used as the main parameter. The derivation of mode choice drivers was aligned with mode choice theory, and the information received from the passenger surveys aided in developing a rank ordered set for the existing rail services. By means of an MCA, the rank ordered set was used to define the hypothetical socio-demographic market segmentation of the PRASA Modernisation service. The potential competitive overlap between the existing Rapid Rail and PRASA Modernisation services were evaluated in terms of a geographical overlap, travel pattern overlap and trip making overlap. Finally, the estimated service uptake was analysed by means of a binary mode choice model and sensitivity testing was undertaken to evaluate the elasticity of potential service uptake.

## 4.1. Data Requirements

This research study required input data focussing on the socio-demographic and travel behaviour in Gauteng. The analysis to understand the driving factors of rail mode choice in Gauteng required the following datasets:

- Socio-economic data
    - National Census 2011
- Origin-destination travel data
    - National and Gauteng Household Travel Survey 2013
- Metrorail passenger data
    - *National Metrorail Customer Satisfaction Survey - Technical Research Report 2013/14*
- Metrorail performance reports
    - Train Performance Reports 2012 - 2016
- Rapid Rail patronage data
    - 2012 - 2017
- Rapid Rail passenger data
    - Passenger Satisfaction Surveys 2016 – 2018
- Rapid Rail performance reports
    - Gautrain Annual Reports 2012 - 2017

The datasets were sourced from Statistics South Africa, PRASA and the GMA.

## 4.2. Data Collection

The literature review guided the data collection phase in identifying what information to obtain for this study. Three data sources were used as follows:

- Statistics South Africa;
- PRASA Business Performance Department; and
- Gautrain Management Agency Statistics Department.

### 4.2.1. National Census 2011 Dataset

The National Census 2011 surveying was undertaken in October 2011 and aimed to survey all occupied dwelling units in South Africa (Lehohla, 2014). The Census 2011 dataset was developed through multiple steps, starting with the fieldwork, followed by data processing, data editing and validating and finally data evaluation. The Census 2011 project was also independently monitored to ensure the production of a reliable data source. The Census 2011 dataset is the latest source of South African population and household information and was thus deemed sufficient to be used in this research study.

The Census 2011 dataset supported this research in terms of population statistics, including population density within the Gauteng Province. The income brackets defined in the Census 2011 dataset was also adopted in this research study in defining the various rail markets. Finally, the Census 2011 dataset consisted of Geographic Information Systems (GIS) information database, which was used as a base for this research study's maps.

### 4.2.2. National Household Travel Survey 2013

The NHTS 2013 surveys were undertaken in the first quarter of 2013 (Department of Transport, 2013). The survey's sample design was based on the Census 2011 enumeration areas and over 10 600 dwelling units were surveyed in the Gauteng Province. Due to the survey being undertaken across the whole of South Africa, the sample size may be considered small (<1%). However, the travel patterns and behaviour related level of detail captured in the NHTS 2013 dataset was valuable for this research study and was considered to be the best available travel behaviour dataset for the study area. It was also the only travel related dataset which included nation-wide travel statistics, which proved useful in benchmarking the Gauteng Province results.

The NHTS 2013 supported this research study by detailing the travel and trip making behaviour of travellers in the Gauteng Province. This dataset also aided in defining the passenger markets of the Gauteng Metrorail and Rapid Rail services, in terms of income, trip purpose, mode choice and origin-destination patterns. Finally, the travel analysis zones (TAZ) defined in the NHTS 2013 were used in this research study as the level of aggregation for the trip making analyses.

### 4.2.3. Metrorail Patronage Data

The Metrorail patronage data was collected through two datasets, namely the 2007 Metrorail Census and ticketing data between 2014 and 2016. The limitations of these datasets exceeded the value they may add to this research study. The 2007 Census data was outdated and when compared to the ticketing data, revealed negative growth trends. These trends are anticipated to be due to the known fare evasion on the Metrorail services. However, without more recent Census data the proportion of fare evasion cannot be quantified. Furthermore, this research study did not focus on Metrorail patronage, but rather Rapid Rail patronage in Gauteng. Therefore, the Metrorail patronage dataset was not used further in this study.

### 4.2.4. Metrorail Passenger Survey Data

PRASA conducted a Customer Satisfaction survey in 2013/2014 (Afrocentric Corporate Services (Pty) Ltd, 2014). The survey was used to evaluate the satisfaction and importance to the commuters' needs against the Metrorail's performance. The survey was undertaken throughout the major cities in South Africa being serviced by PRASA. A total of 968 respondents were interviewed in Gauteng. Without knowing the actual Metrorail patronage today, it is difficult to calculate the sample size proportion. The 2007 Census reported that 590 000 persons use the Gauteng Metrorail on a daily basis, thus the sample size is estimated to be less than 1%. However, the 2013/2014 Customer Satisfaction survey is the most recent and detailed dataset available which describes the Gauteng Metrorail passenger characteristics and how the service is being perceived. It was therefore deemed suitable to use in this research study.

The Customer Satisfaction survey 2013/2014 was used to define the Gauteng Metrorail passenger profile and understand the drivers behind the passengers' mode choice. The survey also described and ranked the passengers' levels of importance related to the attributes and characteristics of the Metrorail service (i.e. mode choice drivers).

### 4.2.5. Metrorail System Performance Data

PRASA monitors the Metrorail system performance using monthly reports which records the number of trains scheduled, cancelled and delayed (PRASA, 2017). The reports are aggregated to report the

Metrorail punctuality for each financial year. The Metrorail performance data between 2012 and 2017 was used in this research study to evaluate the Metrorail system's performance and punctuality.

#### 4.2.6. Rapid Rail Patronage

Detailed Rapid Rail patronage data is captured through the Gautrain Gold Card, which is used across the suite of integrated travel modes (Gautrain, distribution-feeder buses and park-and-ride facilities), and assigns an origin and destination station to each trip made on the system (Gautrain Management Agency, 2018). This research study made use of the 2017 Rapid Rail patronage data, aggregated to the average AM peak hour and daily passenger volumes, to evaluate the patronage on the Rapid Rail system and proportion of trips making use of the park-and-ride facilities. The origin-destination data was also used to evaluate the travel patterns of the Rapid Rail passengers.

#### 4.2.7. Rapid Rail Passenger Survey Data

The GMA conducts passenger satisfaction surveys every 6 months in order to evaluate the passengers' satisfaction with the quality and comfort of the Rapid Rail services and to monitor the trends of satisfaction over time (Gautrain Management Agency, 2016 - 2018). The surveys aim to interview 200 passengers every 6 months. This research study obtained access to the 2017 and 2018 passenger survey results.

The Gautrain passenger surveys were used in this research study to define the Rapid Rail passenger profiles, understand the drivers behind the passengers' mode choice and understand how the passengers ranked the level of importance related to the attributes and characteristics of the Rapid Rail service.

#### 4.2.8. Rapid Rail System Performance Data

The GMA has published Annual Reports detailing the performance of the Gautrain, both as a business and a Rapid Rail system (Gautrain Management Agency, 2018). Annual Reports have been published every year since the commencement of the Rapid Rail service.

This research study made use of the Annual Reports (2012 – 2018) in order to evaluate the Rapid Rail system's performance and punctuality.

### 4.3. Data Analysis and GIS Mapping

The data collected was analysed in order to understand the relationship between the Gauteng Province's socio-demographics, origin-destination patterns, and mode choice drivers (particularly rail).

#### 4.3.1. Existing Rail Services' Socio-demographic Market Segmentation

The Rapid Rail and Gauteng Metrorail passenger surveys and the NHTS 2013 were used to define the passenger markets for the Gauteng Metrorail and Rapid Rail services. The socio-demographic markets were defined in terms of income and trip purpose, as presented in Table 4-1. The four income categories were aligned with the Census 2011 income brackets. The passenger surveys concluded that 84% of passengers using the Gauteng Metrorail service earned a household income of less than R12 800 and 97% of the passengers on the Rapid Rail service earned a household income of more than

R12 800. This data clearly confirmed that the existing rail services serve different socio-demographic markets.

*Table 4-1: Rail Market Demographic Definitions*

| Mode | Metrorail | Rapid Rail |
|---|---|---|
| **Low Income % (R0 - R3 500)** | 19% | 0% |
| **Middle Income % (R3 501 - R12 800)** | 65% | 3% |
| **Upper Middle Income % (R12 801 - R25 000)** | 15% | 22% |
| **High Income % (>R25 001)** | 0% | 75% |
| **HBW Trip Purpose** | 100% | 65% |
| **HBO Trip Purpose** | 0% | 35% |

### 4.3.2. Existing Rail Services' Mode Choice Drivers

The mode choice drivers for the Rapid Rail and Gauteng Metrorail services were defined into five categories; namely travel time, travel comfort, safety and security, service reliability and travel cost, as presented in Table 4-2. The Rapid Rail (Gautrain Management Agency, 2016 - 2018) and Gauteng Metrorail passenger surveys (Afrocentric Corporate Services (Pty) Ltd, 2014) asked the passengers to rank these factors in order of importance to their travel (5 – most important, 1 – least important).

*Table 4-2: Mode Choice Drivers' Ranking for Rapid Rail and Gauteng Metrorail Services*

| Mode Choice Driver | Rapid Rail Passengers | Gauteng Metrorail Passengers |
|---|---|---|
| Travel Time | 5 | 2 |
| Travel Comfort | 4 | 1 |
| Safety and Security | 3 | 4 |
| Service Reliability | 2 | 3 |
| Travel Cost | 1 | 5 |

The survey results indicated that the Rapid Rail and Gauteng Metrorail markets value the importance of the mode choice drivers differently. The most important mode choice drivers for the Rapid Rail passengers is time related. This result links back to the demographic categories of the users, with the Rapid Rail market being predominantly high income. The most important mode choice drivers for the Gauteng Metrorail market is cost related. This result links back to the demographic categories of the Gauteng Metrorail users, with this market being predominantly low and middle income.

### 4.3.3. Development of a Hypothetical PRASA Modernisation Market

*a) PRASA Modernisation Program*

PRASA's Modernisation program will aim to overhaul the existing service and provide an upgraded and improved Metrorail service in Gauteng.

The PRASA Modernisation program (PRASA, 2012) stated that the main objectives of the upgrade project included improvement of the Metrorail rolling stock quality to better passenger comfort and upgrade the Metrorail infrastructure, with specific focus on signalling, to improve service speeds (by up to 10%) and service reliability. The PRASA Modernisation program describes the need for park-and-ride facilities to be considered around the Nasrec node, in support of large scale events in and around

this area. However, the PRASA Modernisation program does not consider commuter park-and-ride facilities at any other stations along the Metrorail network.

*b) Hypothetical PRASA Modernisation Market*

As the PRASA Modernisation service is not currently implemented, mode choice parameters for the future service is unknown. However, the implementation of the envisioned upgrades would meet the needs of passengers who rank travel comfort and travel time highly. PRASA have further indicated that the upgrades would not affect travel cost of the Gauteng Metrorail service, thus it is assumed that the upgrades would result in attracting new markets to the service while maintaining the existing markets at the same time. By considering the impact of the PRASA Modernisation program's upgrades on the passenger market, the hypothetical PRASA Modernisation service market was defined by increasing the ranked order of travel time and travel comfort by one position. The existing Gauteng Metrorail ranking was used as a base, and the improvements in the services were captured by repositioning the order of importance of the mode choice drivers for the PRASA Modernisation service. Firstly, the ranking score for travel time was considered, resulting in the travel time ranking shifting from position 2 to position 3 and service reliability shifting from position 3 to position 4, as shown in Figure 4-2. Secondly, the travel comfort was considered and the ranking position was increased by one increment from position 1 to position 2, resulting in the service reliability ranking shifting from position 4 to position 5. The derivation of the hypothetical PRASA Modernisation market's mode choice drivers maintained the ultimate five ranking positions, as presented in Table 4-3.

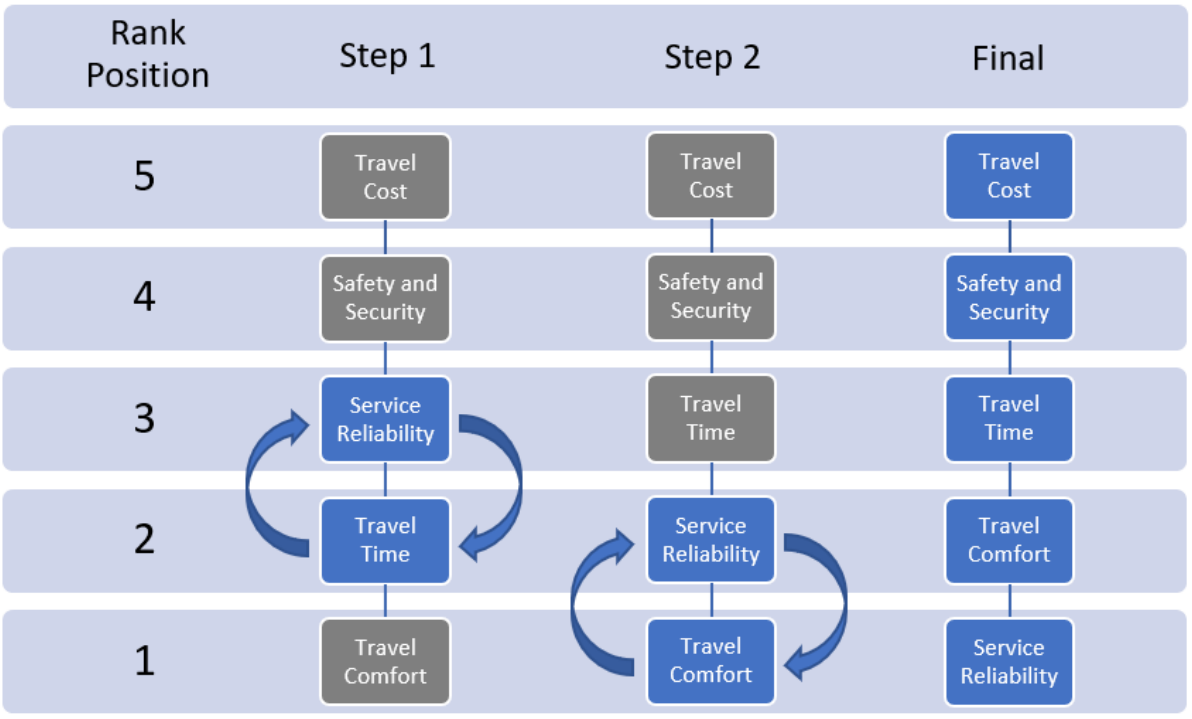


*Figure 4-2: Ranking Order of PRASA Modernisation Service*

*Table 4-3: Mode Choice Drivers' Ranking for PRASA Modernisation Service*

| Mode Choice Driver | Gauteng Metrorail Passengers (base) | Hypothetical PRASA Modernisation Passengers | Change in Ranking due to Service Upgrades |
|---|---|---|---|
| **Travel Time** | 2 | 3 | ↑+1 |
| **Travel Comfort** | 1 | 2 | ↑+1 |
| **Safety and Security** | 4 | 4 | → |
| **Service Reliability** | 3 | 1 | ↓-2 |
| **Travel Cost** | 5 | 5 | → |

It should be noted that without detailed stated preference surveys, as well as revealed preference surveys, being undertaken the above derivation of the PRASA Modernisation market will remain a hypothetical one, making use of available data and ranking assumptions.

### 4.3.4. Rail Market Multi-criteria Analysis

The mode choice drivers' ranking data was used in a point-method MCA by applying a weighting to each category and multiplying each rail service's importance, as derived from the passenger surveys, (ranked between 1 – least important and 5 – most important) to the weighting in order to determine an overall weighted score for each rail service.

The rank sum weight method, which aligned the ranking tiers with each criterion's level of importance, was used to derive the weightings. The weightings were derived by considering the Rapid Rail passengers' ranking of each mode choice driver and aligning the magnitude of the weighting to the level of importance. For example, travel time was considered to the most important mode choice driver for the Rapid Rail passengers, ranking 5 / 15 (0.33) while travel cost was considered the lease importance, ranking 1 / 15 (0.07). The final weighting for each mode choice driver is presented in Table 4-4.

*Table 4-4: Mode Choice Drivers' Weightings*

| Mode Choice Driver | Weighting |
|---|---|
| Travel Time | 0.33 |
| Travel Comfort | 0.27 |
| Safety and Security | 0.20 |
| Service Reliability | 0.13 |
| Travel Cost | 0.07 |

The MCA analysis considered the ranking of the mode choice drivers for each rail market together with the weightings discussed above, in order to derive a resultant score for each rail mode, as presented in Table 4-5. The calculation of the resultant score considered the sum of the product of each mode choice driver's ranking and weighting. The MCA resulted in Rapid Rail obtaining a score of 3.67, the existing Gauteng Metrorail obtaining a score of 2.47 and the PRASA Modernisation obtaining a score of 2.80.

*Table 4-5: Rail Passengers' MCA Results*

| Mode Choice Driver | Weighting | Rapid Rail Passengers' Ranking | Rapid Rail MCA Score | Existing Gauteng Metrorail Passengers' Ranking | Existing Gauteng Metrorail MCA Score | Hypothetical PRASA Modernisation Passengers' Ranking | Hypothetical PRASA Modernisation MCA Score |
|---|---|---|---|---|---|---|---|
| Travel Time | 0.33 | 5 | 1.67 | 2 | 0.67 | 3 | 1.00 |
| Travel Comfort | 0.27 | 4 | 1.07 | 1 | 0.27 | 2 | 0.53 |
| Safety and Security | 0.20 | 3 | 0.60 | 4 | 0.80 | 4 | 0.80 |
| Service Reliability | 0.13 | 2 | 0.27 | 3 | 0.40 | 1 | 0.13 |
| Travel Cost | 0.07 | 1 | 0.07 | 5 | 0.33 | 5 | 0.33 |
| **Resultant Score** | - | - | **3.67** | - | **2.47** | - | **2.80** |

The envisioned improvements of the PRASA Modernisation program placed the PRASA Modernisation market's resultant score between the Rapid Rail and Gauteng Metrorail markets, as presented in Figure 4-3. This result indicates that the PRASA Modernisation service could attract some passengers from the Rapid Rail market. However, the PRASA Modernisation market is still aligned closer to the existing Gauteng Metrorail market as compared to the Rapid Rail market.

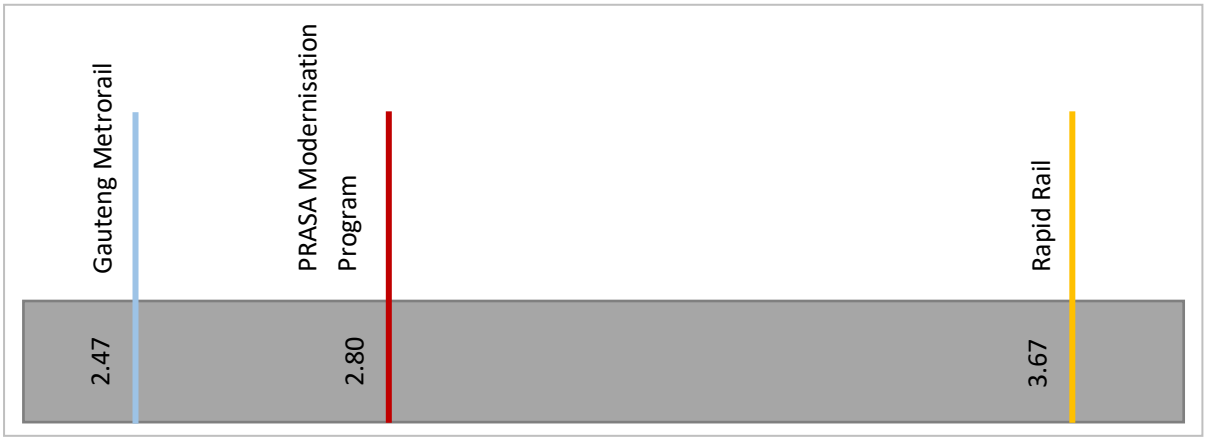


*Figure 4-3: Proportional Illustration of Rail Service MCA Scores*

The proportionate positioning of the PRASA Modernisation markets MCA score suggests that its income distribution is expected to lay between that of the Gauteng Metrorail and Rapid Rail markets without taking up the full Rapid Rail market. As presented in Figure 4-4, the PRASA Modernisation income distribution is expected to expand into the Upper Middle Income category as a result of the service's expected improvements compared to Gauteng Metrorail, but not into the High Income category, as the MCA results placed the PRASA Modernisation well below the Rapid Rail in ranking.

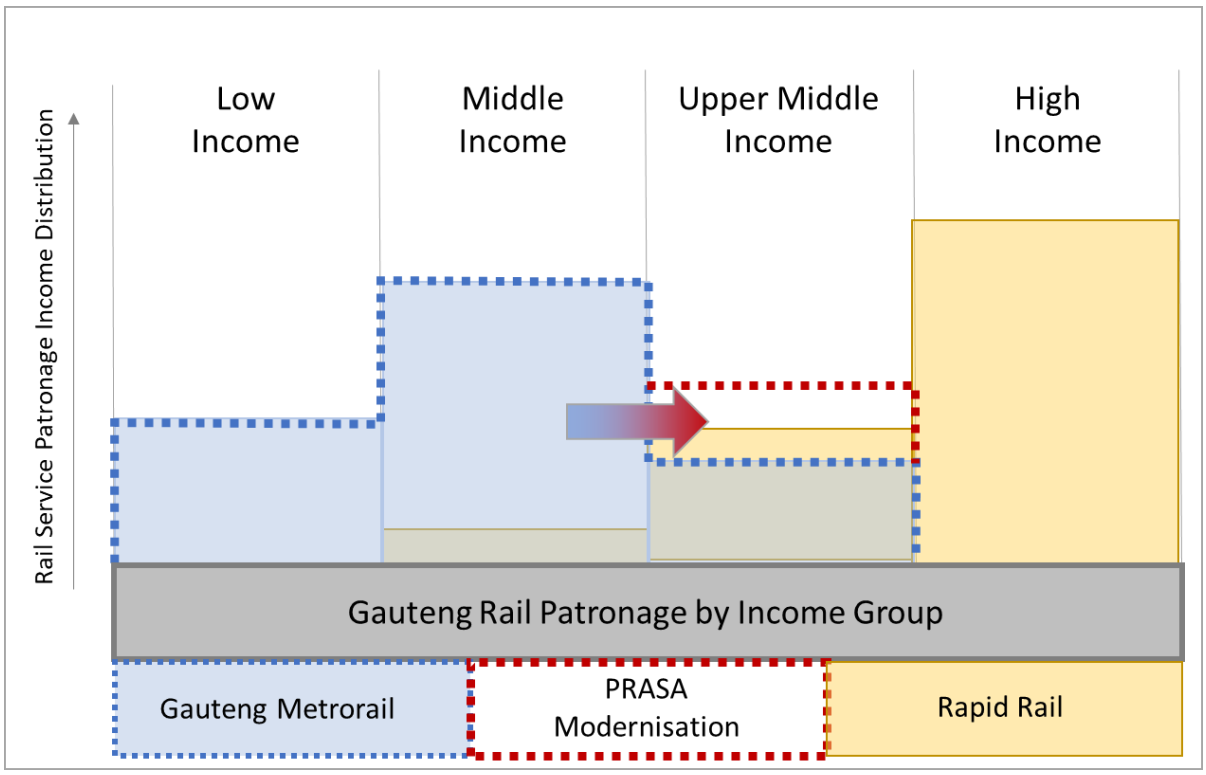


*Figure 4-4: Gauteng Rail Market Distribution by Income*

### 4.3.5. Evaluation of the Potential Competitive Market Overlap between Rapid Rail and PRASA Modernisation

In order to identify the potential overlap in market between Rapid Rail to PRASA Modernisation, the overlap in geographical context and travel patterns between the existing Rapid Rail market and Gauteng Metrorail market were evaluated. It should be noted that the Rapid Rail extensions were not considered as a part of this study. Following the outcome of the MCA discussed in Chapter 4.2.4, the Upper Middle Income population was assessed in terms of residing proximity to the two rail services as well as their origin-destination patterns. Finally, the competitive market overlap in terms of the number of trips which could consider the use of both the Rapid Rail or PRASA Modernisation was quantified and a sensitivity analysis determined the estimate service uptake of this overlap.

# 5. RESULTS AND DISCUSSIONS

## 5.1. Geographical Market Overlap

The Rapid Rail and Gauteng Metrorail station catchments were defined in terms of the access and egress radii to and from the stations. As show in Figure 5-1, the NTHS 2013 indicated that 89% of persons walking to a Gauteng Metrorail station did not walk longer than 30 minutes, equating to approximately 2-kilometres. The NHTS 2013 also indicated that 91% of persons accessing a Metrorail station by bus or minibus-taxi travelled less than 20 minutes, equating to approximately 6 kilometres. The Metrorail catchment areas, as presented in Figure 5-3, were therefore defined as all TAZs with a centroid within a 6 kilometre radius of a Metrorail station.

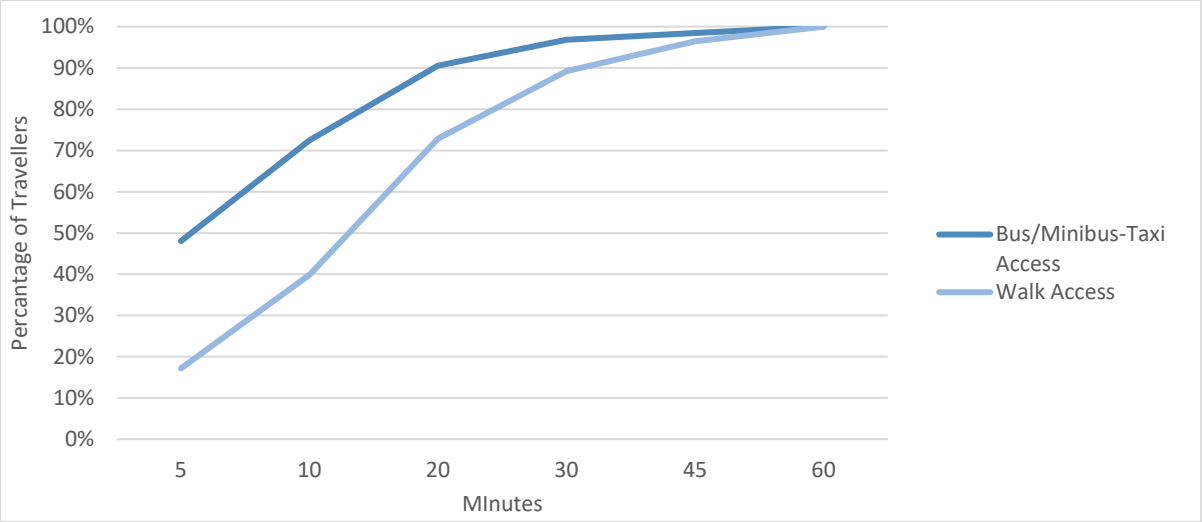


*Figure 5-1: Access Time to Metrorail Station*

The Gautrain commuter surveys provided origin information of passengers in terms of suburbs. This data indicated that 85% of people accessing the Rapid Rail services, travelled to the station from within an 8 kilometre radius, as shown in Figure 5-2. The Rapid Rail catchment areas, as presented in Figure 5-4, were therefore defined as all TAZs with a centroid within an 8 kilometre radius of a Rapid Rail station.

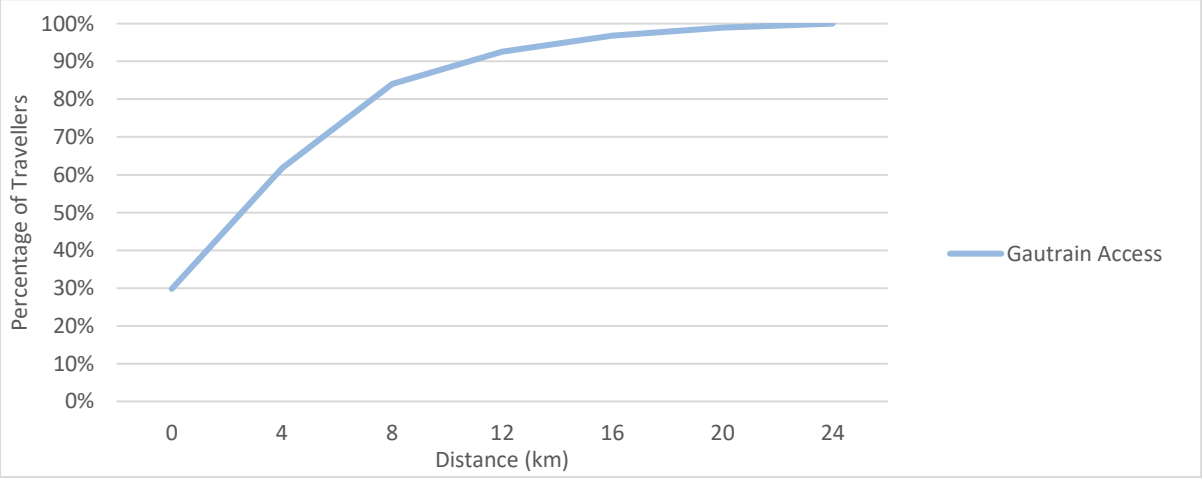


*Figure 5-2: Access Distance to Rapid Rail Station*

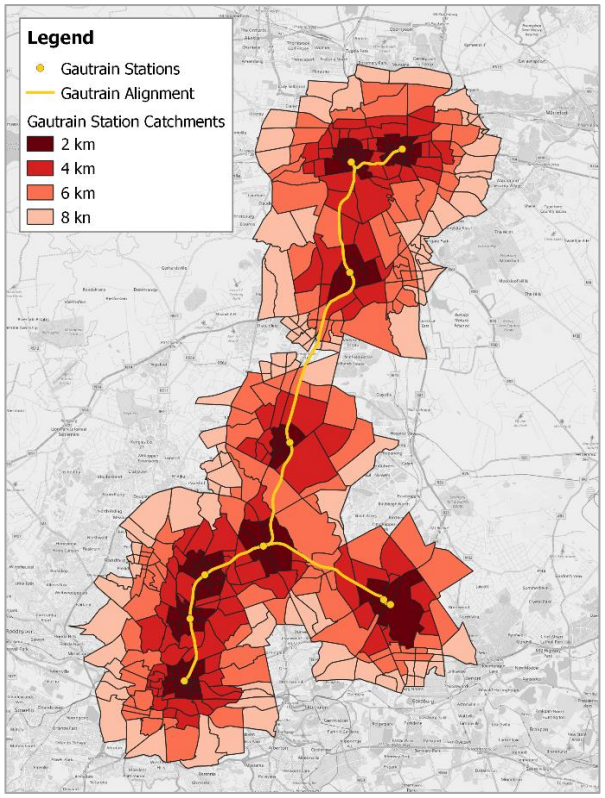


*Figure 5-3: Rapid Rail Station Catchment*

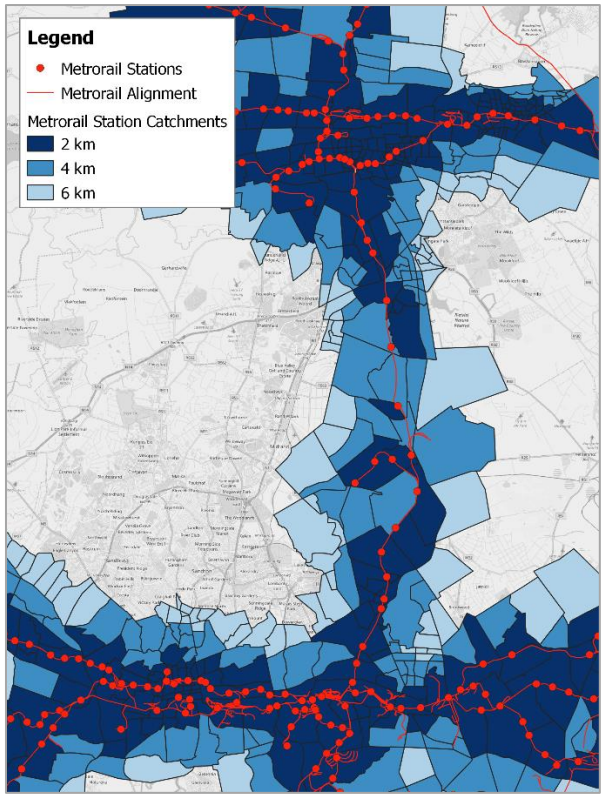


*Figure 5-4: Gauteng Metrorail Station Catchment*

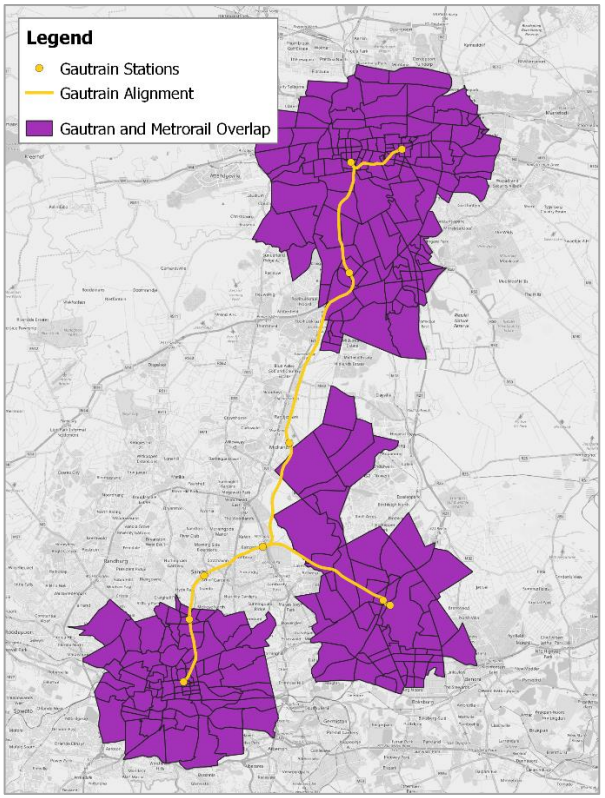


*Figure 5-5: Rapid Rail and Metrorail Catchments Overlap*

A GIS analysis considered these catchments' extents and their geographical catchment overlap was derived, as presented in Figure 5-5. The dominant geographical overlap between the Rapid Rail and Gauteng Metrorail catchments occurs around the Hatfield, Pretoria, Rhodesfield, Rosebank and Park nodes, while partial overlap was observed at the Centurion, Midrand and Marlboro nodes. The Sandton node was the only Rapid Rail station node that did not overlap with the Gauteng Metrorail catchment.

Further to the discussion in Chapter 4.2, the Upper Middle Income population was considered to be the population group which is most likely to consider the rail service shift from Rapid Rail to the PRASA Modernisation service. Table 5-1 presents the total Upper Middle income population who reside in the Rapid Rail station catchments as well as the population residing in the regions where the Rapid Rail and PRASA Modernisation catchments overlap.

*Table 5-1: Population Overlap between Rapid Rail and PRASA Modernisation Catchments*

| Rapid Rail Station | Upper Middle Income Population in Full Rapid Rail Catchment | Upper Middle Income Population in Catchment Overlap Regions | Gauteng Metrorail Overlap with Rapid Rail Station Catchments (Population %) |
|---|---|---|---|
| **Hatfield** | 64,270 | 59,381 | 92.39% |
| **Pretoria** | 37,323 | 37,323 | 100.00% |
| **Centurion** | 45,871 | 30,684 | 66.89% |
| **Midrand** | 46,748 | 29,337 | 62.76% |
| **Marlboro** | 20,784 | 6 | 0.03% |
| **Sandton** | 28,400 | 0 | 0.00% |
| **Rosebank** | 29,294 | 18,294 | 62.45% |
| **Park** | 71,512 | 71,512 | 100.00% |
| **Rhodesfield** | 53,211 | 51,218 | 96.25% |

A 100% geographical and population overlap was observed at the Pretoria and Park nodes. Overlaps greater than 90%, but less than 100%, were observed at the Hatfield and Rhodesfield nodes and overlaps between 60% - 70% were observed at the Centurion, Midrand and Roasebank nodes. The nodes with negligible overlap included Marlboro and Sandton.

It was identified that population alone is not sufficient to determine the potential mode shift from Rapid Rail to PRASA Modernisation services. The reason for travel and origin-destination travel patterns are also important for consideration.

## 5.2. Travel Pattern Overlap

The 2017 Rapid Rail ticketing data was used to investigate the origin-destination patterns on the Rapid Rail service. Figure 5-6 presents the proportion of passenger boardings and alightings at each of the commuter service stations over a typical weekday, AM peak period. The Centurion, Hatfield, Midrand, Park and Rhodesfield stations were observed to have the highest boardings in the morning, between 13 – 20%. Sandton station was observed to be the dominant alighting station in the morning, accounting for 37% of all alightings. The passenger data also indicated that the average trip length frequency for the Rapid Rail passengers is longer compared to road-based transport. The NHTS 2013 stated that the average trip length frequency for HBW trips is between 11 – 20 kilometres. As

illustrated in Figure 5-7, 74% of Rapid Rail trips are longer than 20 kilometres, indicating that the Gautrain provides a longer distance service.

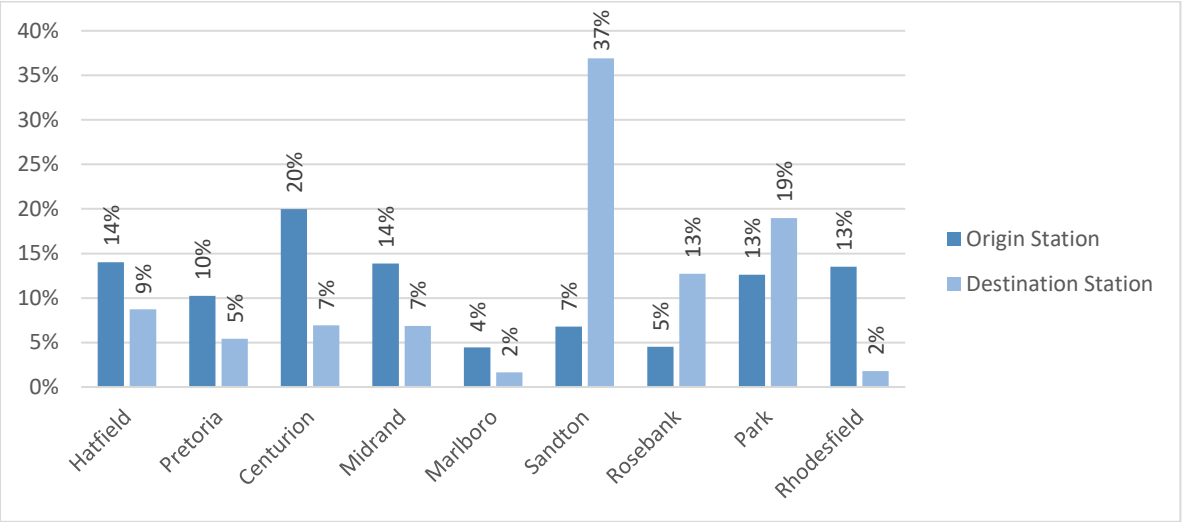


*Figure 5-6: Rapid Rail Patronage Station Distribution*

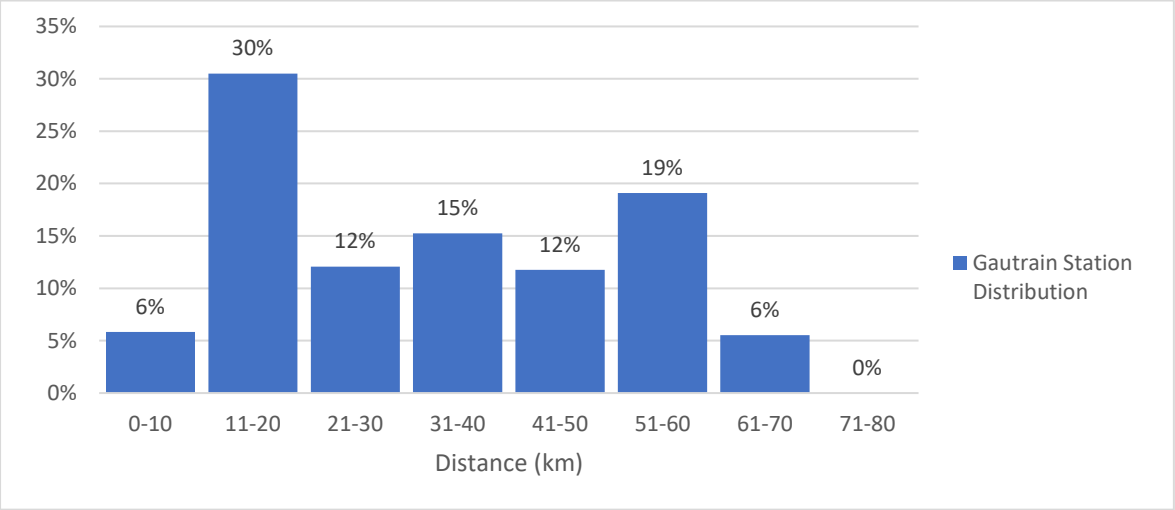


*Figure 5-7: Rapid Rail Station Travel Distance Distribution*

## 5.3. Trip Making Overlap

In 2017, the Rapid Rail service carried 7 800 passengers in the AM peak hour on the Gautrain Passenger Service (GPS) and 51 000 passengers on a typical weekday (Gautrain Management Agency, 2018). As discussed in Chapter 4.2, the Upper Middle Income passengers, making up 22% of the Rapid Rail passengers, are the most likely Rapid Rail passenger group to also consider using the PRASA Modernisation service. Through consideration of the number of existing Upper Middle Income Rapid Rail passengers, Rapid Rail and PRASA Modernisation catchment overlap, the trip distribution of the Rapid Rail passengers and the origin-destination patterns of the existing Rapid Rail passengers, the market overlap between Rapid Rail and PRASA Modernisation services was derived.

The AM peak hour Rapid Rail patronage consists of 1 728 Upper Middle Income passengers. A total of 939 Upper Middle Income passengers travel between origins and destinations which fall within the

PRASA Modernisation catchments. An AM peak hour to daily patronage expansion factor of 6.5, based on the daily patronage profile, was used to estimate the daily Upper Middle Income passengers on the Rapid Rail service. The trip making overlap between the Rapid Rail and the PRASA Modernisation services resulted in 6 100 passengers per day, accounting for 12% of the overall Rapid Rail patronage.

## 5.4. Estimated Service Uptake

Once the competitive overlap market between the Rapid Rail and PRASA Modernisation was determined, the uptake of the overlap market onto each of the rail services was estimated. The overlap market identified the number of existing Rapid Rail passengers who would also consider using the PRASA Modernisation service.

The mode choice utility for the overlapping market was assumed the same, as the market consists of a single socio-demographic group with the same trip purpose, thus assuming that there is no inherent preference for Rapid Rail over the PRASA Modernisation service. The variables considered for the service uptake estimation therefore considered the operational characteristics of the two rail services, namely travel time and travel cost.

The Rapid Rail's average operating speed is 95 km/h. The PRASA Modernisation service is planning on improving existing Metrorail speeds by 10%, thus operating at an estimated average speed of 50 km/h. These speeds were normalised around the best performing service, as presented in Table 5-2. The Rapid Rail fare structure was estimated at R17.77 + R0.77 per kilometre. The PRASA Modernisation service plans to maintain the existing fare structure of the Metrorail service, which is estimated at R5.00 + R0.11 per kilometre. These fares were also normalised over an average trip distance between Pretoria and Johannesburg CBDs, as shown in Table 5-2. The mode choice driver weightings, as defined in Section 4.2.4, were applied to these normalised operational parameter rankings and the sum of the product of mode choice drivers and weightings defined the combined score in Table 5-2. A relative proportion between the combined scores was then calculated to determine the estimated uptake of each rail service.

*Table 5-2: Operational Rankings*

| Mode Choice Driver | Weighting | Rapid Rail | PRASA Modernisation |
|---|---|---|---|
| Travel Time | 0.33 | 1.00 | 0.56 |
| Travel Cost | 0.07 | 0.18 | 1.00 |
| Combined Score | - | 0.35 | 0.25 |
| Estimated Uptake | - | 59% | 41% |

The estimated service uptake resulted in 59% of the competitive overlapping market remaining to use the Rapid Rail service and 41% of the overlapping market shifting to use the PRASA Modernisation service. The estimated uptake percentage equates to less than 5% of the existing Rapid Rail patronage. The elasticity of the service uptake in relation to the travel time and travel cost was also evaluated. Through incrementally increasing and decreasing the travel speed of the Rapid Rail and PRASA Modernisation services, the elasticity of the potential service uptake was found to be inelastic with 0.21 and 0.15 respectively. The travel costs were also incrementally increased and decreased for both services, and the elasticity of the potential service uptake was found to be inelastic with 0.008 for Rapid Rail and 0.004 for PRASA Modernisation. The resulting elasticities had a direct relation to the

weighing magnitudes for both mode choice drivers. As a result, the sensitivity of the PRASA Modernisation service uptake was also tested against the relative weightings.

Firstly, the travel time weighting was kept constant at 0.33, and the travel cost weighting was varied between the five weighting values defined in Section 4.2.4 of this research study. The resulting PRASA Modernisation uptake is presented in Table 5-3. As the weighting of the travel cost increased, the estimated uptake of the PRASA Modernisation service increased, due to the much lower fare on this service compared to the Rapid Rail service. Should travel cost be considered third most important to the Rapid Rail users (weighting of 0.2), the PRASA Modernisation service could obtain a 50% uptake of the overlapping market and could increase to 56% if considered equally important as compared to travel time.

*Table 5-3: Travel Cost Weighting Sensitivity Testing*

| Travel Cost Weighting | PRASA Modernisation Estimated Service Uptake |
|---|---|
| **0.33** | 56% |
| **0.27** | 54% |
| **0.2** | 50% |
| **0.13** | 46% |
| **0.07** | 41% |

Secondly, the travel cost weighting was kept constant at 0.07, and the travel time weighting was varied between the five weighting values defined in Section 4.2.4 of this research study and the resulting PRASA Modernisation uptake is presented in Table 5-4. As the weighting of the travel time decreased, the estimated uptake of the PRASA Modernisation service increased, due to the much higher travel speeds of the Rapid Rail service in comparison to the PRASA Modernisation service. The PRASA Modernisation service could obtain more than 50% uptake of the overlapping market if travel time was considered as important as travel costs.

*Table 5-4: Travel Time Weighting Sensitivity Testing*

| Travel Time Weighting | PRASA Modernisation Estimated Service Uptake |
|---|---|
| **0.33** | 41% |
| **0.27** | 43% |
| **0.2** | 45% |
| **0.13** | 49% |
| **0.07** | 56% |

It should however be noted that the key success of the existing Rapid Rail service is its integration with feeder and distributor modes (park-and-ride facilities and Gautrain buses), linking the Rapid Rail stations to its greater surrounds. The PRASA Modernisation program has not defined any such services as a part of the upgrade and could impact the uptake of the service from existing Rapid Rail users. As discussed in Section 3.1.2 of this study, the Rapid Rail park-and-ride facilities are used by more than 40% of the Rapid Rail passengers. Without this infrastructure, the potential uptake of the PRASA Modernisation service from existing Rapid Rail services could be diminished from 41% to 25%.

# 6. CONCLUSIONS

The Gauteng Metrorail and Rapid Rail services currently serve different passenger markets, with the Gauteng Metrorail serving the Low and Middle Income passengers and the Rapid Rail serving the Upper Middle and High income passengers. The PRASA Modernisation program aims to overhaul the existing Gauteng Metrorail service by means of improvement to the quality of the Metrorail rolling stock to improve passenger comfort and upgrading the Metrorail signalling to improve service speeds and reliability.

The improvements to the Gauteng Metrorail service are expected to have an impact on the attractiveness of the service. As Gauteng only has two rail services, a potential exists whereby the upgraded Metrorail service may become attractive to existing Rapid Rail users and a potential switch in mode choice could occur, resulting in a competitive rail service overlap. However, to quantify the potential overlap in markets between the Rapid Rail and PRASA Modernisation, these services' geographical catchments, market segmentation, passengers' mode choice drivers and trip making behaviour were analysed.

The MCA concluded that the improvements envisioned by the PRASA Modernisation program would not improve the Metrorail service enough to be aligned with the needs of all the Rapid Rail users, but rather be better aligned with the needs of the Upper Middle Income Rapid Rail passengers. Through consideration of the number of existing Upper Middle Income Rapid Rail passengers, Rapid Rail and PRASA Modernisation catchment overlap, the trip distribution of the Rapid Rail passengers and the origin-destination patterns of the existing Rapid Rail passengers, the market overlap between Rapid Rail and PRASA Modernisation services was derived to be 12% of the overall Rapid Rail patronage.

The estimated service uptake resulted in 59% of the overlapping market remaining to use the Rapid Rail service and 41% of the overlapping market shifting to use the PRASA Modernisation service. However, the Rapid Rail park-and-ride facilities are used by more than 40% of the Rapid Rail passengers. Without this infrastructure at the PRASA Modernisation stations, the potential uptake of the PRASA Modernisation service from existing Rapid Rail services could be diminished from 41% to 25% due to the lack of an integrated Metrorail system with private cars. The final competitive overlapping market potentially shifting to the PRASA Modernisation services resulted in 3 – 5% of the total Rapid Rail patronage. This overlap is considered negligible and concludes that even with the upgrades of the PRASA Modernisation program, the two rail services would remain serving different markets within the Gauteng Province. The upgrades of the PRASA Modernisation program will however improve travel condition for existing Metrorail users and could potentially attract new passengers from other modes of transport. In quantifying such benefits a similar study could be undertaken which considers the potential overlap between the PRASA Modernisation program and other modes of transport, such as minibus-taxis, buses and private car.

# 7. RECOMMENDATIONS

This research study concluded that the competitive overlap between the Rapid Rail and PRASA Modernisation services would be negligible as these services will continue to serve different markets. It is therefore recommended for the PRASA Modernisation program to be implemented to assist in the much needed rejuvenation of the Gauteng Metrorail service.

In order for rail to serve as the backbone of the Gauteng public transport system, it is further recommended that the PRASA Modernisation program incorporates integrated feeder and distributor services both for public transport users and private care users. An integrated feeder and distributor network would meet the needs of the top mode choice drivers for the PRASA Modernisation market. Firstly, an integrated ticketing system could simplify travel cost by using a single ticket or travel card throughout the entire trip. Travel costs could potentially also be reduced through incentives to use multiple modes within the system. Secondly, an integrated system would require stringent monitoring and maintenance on all modes of transport, thus safety and security could improve from the current state. Lastly, an integrated system will improve reliability, by means of efficiently integrated timetables between the various modes and Intelligent Transport Systems communicating travel information to the passengers. The Gautrain integrated system could be used as a successful case study from which to draw information on how to implement an integrated transport network.

One of the limitations of this study was the market definition of the future PRASA Modernisation service. It is therefore recommended that market related surveys be undertaken to better understand the updated Metrorail service's market. Stated preference surveys would benefit the understanding of the future service's mode choice drivers and confirm whether there is indeed no inherent preference for Rapid Rail over the PRASA Modernisation service.

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